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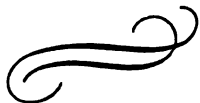
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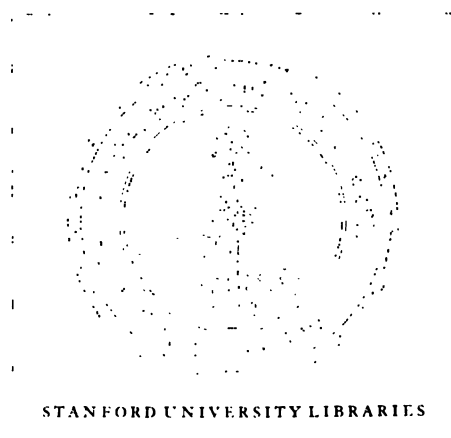


A MEMORIAL

BY

W. SARTORIUS VON WALTERSHAUSEN





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G A U S S

A MEMORIAL

by

W. SARTORIUS VON WALTERSHAUSEN
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LEIPZIG

Publisher: S. Hirzel

1856

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Translator's Note

The translator, a great-granddaughter of the mathematician, wishes to call attention to the fact that the writer of this Memorial, Baron Wolfgang Sartorius von Walthershausen, Professor of Geology at the University of Göttingen, wrote over one hundred years ago and immediately after the death of his long-cherished friend and colleague. This to some extent explains the extreme feeling and language of the Memorial. In the interests of clarity the somewhat archaic German has been given a very free rendering.

In a personal letter to the translator, dated August 5, 1949, Dr. Albert Einstein wrote as follows:

"The importance of C. F. Gauss for the development of modern physical theory and especially for the mathematical fundament of the theory of relativity is overwhelming indeed; also his achievement of the system of absolute measurement in the field of electro-magnetism."

Helen Worthington Gauss

June 26, 1966
Colorado Springs, Colorado

AUTHOR'S FOREWORD TO THE GERMAN EDITION

Soon after the great man to whose memory these pages are dedicated had closed his searching blue eyes came the thought that a voice should be raised from this scene of his activity which extended from his early years through almost half a century. This voice should be that of one who loved him and would describe his life in a manner befitting his immortal name and also the honor of our "Georgia Augusta."*

I know well that I can but incompletely meet the demands of this task that has been put upon me, yet I may be allowed to sketch the life of this great spirit towering high over his century, not with the intention of raising a monument to him (this he does not need) nor with a view of bringing into one wide compass his inspiring discoveries. This is a task the full reach of which will presently be undertaken from another angle. I seek rather to acquit myself of a sacred obligation. At a time when our great loss is still a living sorrow I would sharply engrave upon our minds the memory of him who has left us.

My desire is to give my readers a true picture of the man to whom no nation of today can present an equal, to grasp his forthright simple personality. With the warmth of my own feeling I would remind the oncoming generation of his Heaven-sent influence, for it is upon the foundation of his profound researches that they will be building.

Also, since I am in possession of thoroughly reliable source material from which this sketch is drawn, I wish to correct certain erroneous rumors which have been given publicity. Now I give it to the public, hoping it may find a friendly reception among the many students and admirers of the great mathematician, and may also create a wider interest.

From time to time in world history highly gifted, rarely endowed natures have stepped forth from the murk of their surroundings and through the creative force of their minds and the energy of their achievements have exercised a surpassing influence upon the spiritual development of nations. They stand like boundary stones between different centuries. From them new trends have come into Man's civilization.

As such pioneer spirits we have in the history of mathematics and the natural sciences Archimedes of Syracuse for ancient times, Newton after the close of the Middle Ages, and for our day Gauss, whose life was ended this year, 1855, on the 23rd day of February.

During his life we saw in him an extraordinary spirit, mightily striving, richly endowed by nature with very great gifts. To his profound power of thought was added an amazing memory. He had moreover a strength of will which carried him through seemingly impossible tasks.

From such a mind, uniting varied and rarely combined talents and sustained by a strong body, have come in the past sixty years creations of genius which have moved to reverence the most profound thinkers of our time, an honor to our century.

Gauss' life was dedicated to that free science which refuses to be narrowed to practical applications and which is placed of its own right with the stars above, to proclaim the immortal in the soul of Man. This loftiness of thought guided Gauss throughout life and is now left as a sacred legacy to our University, that far into the future pure science may live on in our midst, vigorous and vivifying.

Carl Friedrich Gauss was born April 30, 1777, in a small poor house on the Wendengraben in Braunschweig, of parents in humble circumstances. His father's father lived in the country and about 1740 moved to Braunschweig to settle there and support himself chiefly with gardening. He had three sons of whom Gauss' father, born in 1744, was the second. The other two, of whom no descendants are known, died much earlier than he.

Gauss' father held the title of Master of Waterworks and followed a variety of occupations. In time these brought him a kind of prosperity and he gave up most of them. For the last fifteen years of his life - up to his death in 1808 - he retained only a little gardening business. Also he assisted a merchant in the Braunschweiger and Leipsiger Fair and since he wrote and reckoned well managed a small office for a large Burial Insurance Society, recording and collecting payments. He was a completely upright, estimable, well respected man. But at home he was dictatorial and harsh. It was natural that Gauss as a child could not turn to him for understanding. Yet there was no discord between them, for Gauss early became wholly independent.

Gauss' father was married twice. By the first marriage he had a son George, born in 1768, who left his father's home early to learn a trade, moved about to different places, and in 1794 returned to Braunschweig because of serious eye trouble which had forced him to give up his trade. But the father tolerated no idleness, and the son turned soldier since it was too late to learn a new trade. On the side he helped his father in all his business. In 1806 he withdrew from military service, and on his father's death two years later became manager of the Burial Society, holding this office up to the day of his death, August 7, 1854.

Gauss' grandfather on his mother's side, Christopher Benze, was a stonemason in the village of Velpke, five miles from Braunschweig. Through his work he contracted consumption and died in his thirtieth year, leaving a daughter Dorothea and a younger son Friedrich. The son learned weaving and soon, without instruction from others, was doing artistic damask weaving, showing in general an intelligent, keen brain. Gauss as a child found great pleasure in his clever uncle and in later years found still more, leading him into talk on stimulating, challenging subjects. He saw in him unusual gifts and always regretted his early death, saying: "A born genius was lost in him."

The daughter Dorothea, born in 1742, came to Braunschweig about the year 1769 and married Gauss' father in 1776. She had a naturally clever mind, a straightforward, humorously gay disposition and a strong character. Her great son was her only child, her pride and joy. She clung to him, as he to her, with warm devotion up to her last hour. She was of strong constitution, but completely blind from cataract the last four years of her life. She died in April, 1839, at the age of ninety-seven, at our Goettingen Observatory, where she had lived with her son for the last twenty-two years of her life.

As long as he lived Gauss cherished memories of the narrow little homecircle of his childhood. In old age he liked to recall characteristic little episodes which reflected the outwardly restricted, modest homelife, but in which one detected the sparks of genius which later rose to such heights. He remembered these incidents accurately and in recounting them he never varied the details. His amused and cheerful telling gave them a delightful charm which would be lost were they to be repeated in print.

When very small, he recalled, he was once near death. The Wendengraben on which his parents lived was in those days an open canal connected with the Ocker river, and in the spring was full of water. The little fellow was playing by it one day, when he fell in, to be saved just as he was sinking, as if preserved by Providence for his high achievements in the world of Science.

While still very young Gauss showed rare mental gifts. He learned to read by asking one or another in the home the sound of the letters. His marked aptitude for numbers and his ease and accuracy in mental arithmetic soon attracted the attention of his parents and their friends. He used to say jestingly that he learned to count before he could talk.

Gauss' father carried on in the summer a masonry business. On Saturday evenings it was his habit to pay his workmen their past week's wages, paying those who had worked overtime according to the extra hours they had put in. On one such occasion he had finished the reckoning and was about to pay out the money when there came a childish voice from a small bed in the corner of the room. Unnoticed the three-year old child had been following his father's transactions. Now he said, "Father, the reckoning is wrong. It is so much," naming a certain figure. The reckoning was gone over again and was found to be what the child had said.

In 1784 after his seventh birthday the little fellow entered the public school where elementary subjects were taught and which was then under a man named Büttner. It was a drab, low school-room with a worn, uneven floor. On one side one looked out on the two slender Gothic towers of the Catharinen Church, on the other side were stables and poor back-yard dwellings. Here among some hundred pupils Büttner went back and forth, in his hand

the switch which was then accepted by everyone as the final argument of the teacher. As occasion warranted he used it. In this school--which seems to have followed very much the pattern of the Middle Ages--the young Gauss remained two years without special incident. By that time he had reached the arithmetic class in which most boys remained up to their fifteenth year.

Here occurred an incident which he often related in old age with amusement and relish. In this class the pupil who first finished his example in arithmetic was to place his slate in the middle of a large table. On top of this the second placed his slate and so on. The young Gauss had just entered the class when Büttner gave out for a problem the adding of a series of numbers from 1 to 100. The problem was barely stated before Gauss threw his slate on the table with the words (in the low Braunschweig dialect): "There it lies." While the other pupils continued busily adding, Büttner, with conscious dignity, walked back and forth, occasionally throwing an ironical, pitying glance toward this the youngest of the pupils. The boy sat quietly with his task ended, as fully aware as he always was on finishing a task that the problem had been correctly solved and that there could be no other result.

At the end of the hour the slates were turned bottom up. That of the young Gauss with one solitary figure lay on top. When Büttner read out the answer, to the surprise of all present that of young Gauss was found to be correct, whereas many of the others were wrong. Büttner now decided to write to Hamburg for a new book on arithmetic which would be better suited to the young lad's exceptional mind. But before long he is said to have had enough insight to declare that Gauss could learn nothing more in his school.

Assisting Büttner at the time was a young man by the name of Bartels whose task it was to assist the younger boys with the cutting of their quill pens and with their writing. Since he also was interested in mathematics a close friendship developed between him and the 10-year old Gauss which later had importance for the life work of both. Bartels was able to procure some useful books on mathematics which the two young people studied together. Gauss thus became fully acquainted with the Binomial Theorem in complete generality and soon thereafter with the Theory of Infinite Numbers which opened the way for him into Higher Analysis.

To Bartels also is due the special credit that he drew the attention of several prominent people in Braunschweig to the genius of the young Gauss. Among these was the State Privy Councillor von Zimmerman, a man of unusual insight and lovable character, who soon perceived the extraordinary mental ability of the young lad and developed a warmly affectionate interest in him. Out of this there grew with the years an even closer personal friendship--Gauss never spoke of him without expressions of deep gratitude and affection.

Besides Zimmerman we should recall Privy Councillor von Feronce who helped Gauss in like manner. Through these two men the attention of the Duke Carl Wilhelm Ferdinand was first called to the young mathematician.

Bartels remained throughout his life in the most friendly relationship with Gauss. At Michaelmas, 1788, he left the Büttner school to study at the Collegium Carolinum, went from there to Switzerland, next filled a position in Casan, and was finally honored by being called to be professor of mathematics at the University of Dorpat

Here he died at the age of 68 years. Gauss gratefully honored him to the last as an old friend, put a high value on his noble and generous mind and respected him as a mathematician.

In 1788 after four years in the Büttner school Gauss entered the Gymnasium, almost against the will of his father. Through private study and the help of some older friends he was already well grounded in the classical languages and was immediately taken into the second class. Here he mastered the classical languages with such rapidity (it was only to these languages that any attention was paid at the time) that he amazed both teachers and fellow pupils. After two years he went into the first class. It was then that the Duke Carl Wilhelm Ferdinand had his attention called to the young genius. He expressed his desire to become acquainted with him and in 1791 Gauss was presented at Court.

While all the company enjoyed the arithmetical prowess of the shy 14-year old boy it was the Duke whose fine tact won his confidence. It was he who also could provide for the further development of such remarkable talent. Gauss left the distinguished gathering with many gifts; from Feronce his first logarithmic tables. In 1792 provided for by the Duke, he entered the Collegium Carolinum.

Here he perfected himself in the classic languages and studied the modern. We know that he also busied himself in those years with deep mathematical problems, and that through the works of Euler and Lagrange he widely extended the range of his studies. From Newton's Principia he seems to have absorbed both the divine spirit and the method of that immortal mathematician.

From the Collegium Carolinum Gauss went on to the University of Goettingen. On October 11, he left Braunschweig for Goettingen, not yet fully decided whether to devote himself to philology or mathematics. At first he attended philology lectures at the home of Heyne and found them of great interest. Kästner's lectures on mathematics appealed to him less. He busied himself the more zealously therefore with researches of his own, and in the next two years made several of his most important and celebrated discoveries.

In 1795 he discovered the method of least squares and in the following year, 1796, on March 30* he discovered the theory of the division of the circle, involving the construction of the 17-angled polygon. This discovery he highly prized to the end of his life. It determined the course of his career, for from that day forth he was firmly resolved to devote his life to mathematics.

Gauss seems to have formed very few friendships during his student days at Goettingen; of those known to us only two are living today. The younger is Regierungs-Präsident Eschenburg at Detmold, with whom Gauss' friendship began in 1789 when they were boys at school together. Eschenburg entered the University two years later than Gauss, but through the year 1797 and part of 1798 was closely associated with him. Somewhat older and now a hoary old man of eighty years was Wolfgang Bolyai, of Maros Vasarhely in Siebenbürgen, a man of outstanding powers. Of him Gauss is said to have remarked in his

* Noted in his own handwriting in his copy of the Disquisitiones, p. 662.

earlier years that Bolyai was the only one who could understand his metaphysical view of mathematics. To judge by the few things we have from Bolyai's pen (in a style which reminds us of Jean Paul's writings) he is a man of great depth and sincerity of character. He lives in a remote part of his country, separated from kindred souls and now in his old age surrounded by turbulent revolution, by murder and the horrors of civil war. Through the tears and suffering we have brought upon ourselves he looks out over the ruins of his property toward Eternity, with noble calm and serene assurance. He deplores only that he was not granted the privilege of making his own way, for with but few exceptions life has been made easy for him. "Anyway," he says, "here I am on the earth with my fellow-worms, each of us busy with his own web. Presently I shall come to rest in a nameless grave, reconciled with destiny."

A close University friend of both men was a young Ide of Braunschweig. Like Bolyai he remained in Goettingen a year longer than Gauss and kept in touch with him through correspondence. In a letter to Gauss dated May 23, 1799, he recalls their mutual friend's unusual personality in these words: "Bolyai will attend the coming shooting-fete, but only as a philosopher who finds material in such things for expounding his views on Man's foolishness. So far as I can figure it out, this is his principle; to forego no such occasions, not that they give him pleasure, but that they confirm his own peace of soul."

Connected with Bolyai also was a correspondence between Gauss and Benzenberg which lasted over many years.

Benzenberg's first letter asks Gauss a question, recalls meeting him, and adds: "Bolyai is one of the rarest men I have ever seen."

These are the student friends of Gauss who are till now spared by death. In the youth of these men came the fullest blossoming of our German literature, the purest scientific aspiration, the profoundest zeal for an exalted ideal. Whereas now in our highly enlightened time through uninspired teaching and the deplorable urge to turn science only to practical uses, there is spreading throughout our nation an endless bare field of mediocrity where evidence of originality can only too easily be stunted.

By Michaelmas of 1798 Gauss had completed his studies in Goettingen. From him had already come works of high genius. Now he returned to Braunschweig to oversee the publishing of his Disquisitiones arithmeticae.

In September of this year he went to Helmstedt, not to study at the University, but to use the Library there in connection with the publication of the above-named work. The librarian Bruno he found very cordial and obliging. He also became acquainted with Pfaff and spent an hour or two with him. But only in the next year when he returned to Helmstedt to continue his work was there any closer acquaintance between the two mathematicians. Gauss now went to live in Pfaff's house, in one room which he furnished himself. He worked so strenuously and continuously however that he seldom saw his housemate till evening when they often went for walks together, to the Spring or to Harpke, discussing mathematical subjects at length as they walked. In this exchange of thought Gauss believed he gave more than he received.

We feel called upon to go somewhat at length into the relationship of these two mathematicians since

several times recently, first in a published biography of Pfaff, and in several articles published since, it has been said that Gauss went to Helmstedt to study under Pfaff and was led by him into his mathematical research.

Gauss has indeed very generously recognized and honored Pfaff's mathematical talent and his thorough scientific research, but he himself possessed such a completely original mind that he did not need to be led by another to those discoveries so inspired by genius, so revered by all mathematicians, at a time moreover when his Disquisitiones arithmeticae was in all essentials complete, was in fact already in proof. All his splendid research came from the profound depths of his own genius, developed with such originality and perfection of form that it carried no trace of other influence. This noteworthy quality we see in the work of his earliest youth as well as in that of his last days, as his scientific legacy will presently reveal more clearly.

The Disquisitiones arithmeticae had its inception in the fall of 1795. After various interruptions had dragged the printing through four years, it was finally published in 1801 with the help of the Duke of Braunschweig. Only the most eminent minds in this field are qualified to give a complete and adequate evaluation of this work, so renowned and epoch-making in the history of science. Gauss' own judgment of it, given in the late evening of his life, has interest for the penetrating mind of the scientist as well as for a wider circle of friends.

"The Disquisitiones arithmeticae belong to history. In a new edition, to which I am not disinclined but for which I now have no leisure, I would change nothing but the misprints. I would only like to add the eighth section which was worked out in essentials at the time of the first printing, but did not appear at that time in order not to increase the costs."

Gauss once said in a letter to Bolyai that he hoped in time to furnish so many additions to this work that they would make up a second volume of the Disquisitiones. These investigations to which Gauss referred were later set down in part in the "Commentationes" of the Royal Scientific Society. Some smaller treatises, such as a contribution to the theory of imaginary numbers are to be found in the Goettingen "Scientific Anzeigen." Higher mathematics remained the favorite study of the great mathematician to the end of his life. In his old age he lamented that for these tasks demanding so much sustained exertion he had never been granted the necessary leisure.

The Disquisitiones arithmeticae its author gratefully dedicated to Duke Carl Wilhelm Ferdinand of Braunschweig. This work assured him fame, for with its appearance there begins a new epoch for the theory of numbers in mathematics. Material advantages did not come to Gauss from this work, for a great part of the commissions due him from a book-dealer in Paris were lost through the latter's bankruptcy.

In this connection it should be mentioned that the Disquisitiones have long been out of print and that the gifted young Eisenstein (his career cut short by an early death) was never able to own an original. Likewise other pupils of Gauss copied this work from beginning to end because of the lack of printed copies. Learned mathematicians of this century may be seen on their travels carrying thoroughly thumbled copies like priests going about with their prayer-books.

One would think a work of such compass and profundity would have demanded all of its author's time and interest from the time of its beginning to its completion. It is therefore amazing that besides this great work Gauss was carrying on other important investigations reaching into

widely varied aspects of mathematics and of theoretical and practical astronomy, each in its own way breaking new paths. In that period of his life such an extraordinary richness of thought sprang day and night from the mind of this youthful genius, that one discovery tumbled over another almost too fast to be set down even in outline. Thus some of his greatest discoveries lay to one side--most of them for more than a decade, some for even half a century--before they were made known to the scientific public.

To cite one instance, Gauss arrived at the theory of least squares in 1795. Not till 1799 did his "Disquisitiones" appear, for which he received his doctoral degree "in absentia" while in Helmstedt. The thesis was entitled "Demonstratio nova theorematis omnem functionem algebraicam, rationalem integram unius variabilis in factores reales primi vel secundi gradus resolvi posse." It may be this treatise known as "Disquisitiones arithmeticae" which gave rise to the erroneous impression that Gauss was a student in Helmstedt and there received his degree.

Again in 1797 Gauss found a new, thoroughly rigorous and simple proof of Lagrange's Theorem, which by a mischance was never given publicity. Gauss sent this to Pfaff, and Pfaff forwarded it to Hindenburg who died soon afterwards. The enclosed manuscript was never seen again. Gauss never published his proof, of which there is still a copy, since he found later that Laplace had hit upon a similar solution for this problem. Among other things Gauss further found a new method for reckoning Easter.

In 1801 the wide-spreading fame of his notable achievements brought him his first public tribute, of a kind which later poured in on him in such numbers. The St. Petersburg Academy of Science on January 31

elected him a corresponding member. The official announcement of this he received through State Chancellor von Fuss who from then on always remained in correspondence and close touch with him. With keen interest von Fuss conducted the negotiations which soon afterwards were initiated, and later several times renewed, through which the Russian Government sought to win Gauss for the Petersburg observatory. Fuss' last letter, like his first, brought word of the conferring of an honor. In 1824 he announced that on March 24th Gauss was named a Foreign Member of the Academy. On the 24th of January, 1826, Fuss died in Petersburg in his seventy-first year.

While Gauss even before his twentieth year was on the one hand reforming the various branches of higher mathematics, he was active on the other hand and with equally great success so far as equipment permitted, as a practical astronomer. The observation of comets, eclipses, latitudes and longitudes, etc., was his great joy. His discoveries in the field of pure mathematics, profound as they were, were naturally confined for some time and even up to the present, to a very narrow circle of thinkers. Another discovery had to be recorded--in astronomy--before Gauss' name became known to the larger public as one of the most celebrated in Europe.

On January 24th, 1801, Piazzi in Palermo wrote to Bode in Berlin that he had discovered on the first day of the new century a small comet, like a star of the 8th magnitude without nebula, at $51^{\circ} 47'$ right ascension and $16^{\circ} 8'$ north declination. Some days later Zach*, already informed of Piazzi's discovery, received a letter from Oriani in Milan with the same news and with the comment that Piazzi took the new star, which he had observed on several different days in January, to be a planet. Oriani tried immediately and eagerly to find this newcomer in the skies. But neither Oriani nor any of our German

* Publisher of Zach's monthly Correspondenz.

astronomers who scanned the heavens with such care could find it, since Piazzi's letter from Palermo to Milan was seventy-one days on the way during which time the star had gone down in the twilight.

Meanwhile Olbers also had received the noteworthy news and had immediately calculated a circular orbit from two positions, at the same time expressing the fear that even with the help of his elements the planet could not again be located after its course passed the sun. After much delay Piazzi's observations of the new star finally reached Paris and were next discussed by Burkhardt. He also soon found as had Olbers that no parabolic orbit would conform to the course of the new star. He therefore calculated a circular orbit which deviated somewhat from the approximately circular orbit hit upon by Olbers, and somewhat later he calculated an elliptical orbit, the elements of which were immediately made known through Zach's monthly Correspondenz.

Toward the end of the summer of 1801 astronomers everywhere were turning their attention to Piazzi's new planet which he had meanwhile named "Ceres Ferdinandea". But even the most careful investigations were without result. In early December with all efforts still fruitless Zach made the following important announcement.

"Great hope of help comes to us from the investigations and calculations of Dr. Gauss in Braunschweig, just received. They give us new and highly probable grounds for believing that the star discovered by Piazzi is truly a planetary body moving according to Kepler's laws between the orbits of Mars and Jupiter. We hasten to make this announcement of his calculations since his new elliptical orbit differs considerably from the ellipse of Dr. Burkhardt and from the two circular orbits of

of Olbers and Piazzi announced in our previous issues, and since moreover their deviations from the Gauss positions may amount this present month to as much as six to seven degrees in geocentric longitudes. It is therefore important to make this known as soon as possible to practical astronomers, that they may understand the need of extending six to seven degrees further to the east the section of the heavens in which this new and elusive star is to be looked for.

"Dr. Gauss was led into these calculations by some investigations into physical astronomy which led him to some rather significant additions to the theory of motion of heavenly bodies in conic sections of every kind and which he was so kind as to communicate to us. We hope to bring this to our astronomical readers another time, since to deal with it now in any detail would lead us too far from the present subject. We confine ourselves therefore to what directly concerns the course of Ceres Ferdinanda."

There follow next the elliptical elements of Ceres reckoned by Gauss' theory from Piazzi's observations of January 2nd, 22nd and February 11th, 1801. Immediately afterwards there was given out a second series only slightly different from the first, which placed all nineteen observations most favorably within the announced limits. Shortly thereafter came two new systems of elements for this planet based on more refined observations taken from Piazzi's own hand-written communications, together with an Ephemeris reckoned up to the year's end, for facilitating the search.

At last, as Zach relates it, the united and untiring efforts and zeal of all Europe's astronomers succeeded in finding again this significant planet of our system, discovered first a year before and now re-discovered like a

grain of sand on the shore of the sea. The discovery was made by Zach on December 7, 1801, and by Olbers on January 1, 1802, on the anniversary of the first discovery. Concerning this extension of knowledge so important to astronomy Zach wrote further:

"Ceres is now easy to find and can never again be lost, since the ellipse of Dr. Gauss agrees so exactly with its location. Only those who know from theory how difficult it is to close an orbit of 360° from the scanty data available from Piazzi's forty-day observations covering an arc of only 9° can adequately evaluate and appreciate the ability and powers of penetration possessed by Dr. Gauss."

Olbers writes concerning the same discovery: "You will have noted with pleasure how exactly Dr. Gauss' ellipse agrees with the observations. To show my very special esteem please say this to the worthy scholar: without his laborious investigations of the elliptical elements of this planet we should perhaps never have found it again. At least I would never have looked for it so far to the east."

Piazzi expressed himself in similar strain. Universal admiration was accorded Gauss at that time, and will continue to be accorded him by men of science, for the energy and devotion with which he gave himself to the gradual correction of the Ceres orbit. With every letter to Zach he sent newly determined reckonings. It is hard to credit the ease with which in such a short time he was able to produce such weighty investigations and extensive calculations. Just twenty-four years old, he had already developed these highly original methods while also pursuing much deeper research.

In connection with the discovery and rediscovery of Ceres, Zach tells of a letter which he received in April,

1801, from another country, in which the writer makes a jest of the efforts of astronomers everywhere and suggests that there is a point at which it is well to refrain from building air-castles. Zach comments: "In this connection we can't refrain from quoting part of a letter from Dr. Gauss which reveals the outstanding characteristics and manner of thinking of this great scholar: 'It is hardly conceivable' writes Gauss, 'that men of honor, priests of science, can show themselves in such a light. As for me, I look on all such opportunities as tests of whether I am working for myself or for Science!' Zach continues: "These then are the burdens of Fame, and Gauss will meet many more of them now that he is beginning to write. But to such a mind as his, full of conviction and of aspiration, working only for science, such burdens will never be oppressive. Neither will they put him out of tune with his own age, nor embitter him. We urged him indeed to stand firm on those noble principles on which we likewise would wish to stand, and to recall the following moral-political-mathematical formula of our ever gay, happy and honored old Patriarch and Teacher, Citizen Lalande, Dean of Astronomers:

"Result of a calculation mathematical, political
and moral

There are a thousand million people living on
this earth.
Of these thousand million heads
How many are wicked, foolish, bestial
But we cannot cure, we can only pity and serve
them."

Perhaps this is the place to quote part of a letter from Privy Councillor von Zimmerman of Braunschweig. Ich Zimmerman wrote to Zach: "Incidentally it may not be unpleasant for you to know that Dr. Gauss is indeed a very high-minded, un-selfseeking young man (he is only twenty-four). When I informed him that our excellent society was voluntarily granting him a stipend of 400 Reichsthaler, he said, 'But I have not earned it. I haven't yet done anything for the nation.' Accordingly he planned to buy a sextant to put to use on surveys."

Thor's note:

I would scarcely have included the above quotation in these pages had I not come upon it only yesterday (March 24) in a way to arrest my attention. It is now more than a half-century since the Ceres investigations of Gauss were given out. Perhaps no man living has seen the original of this work. Yesterday evening for the first time since February 23rd (day of Gauss' death) I entered the deserted, quiet little work-room of the man now gone from us. A cabinet was kindly opened for me where were notebooks containing unsuspected treasures for his scientific legacy. A small book, one of the first I took up, bore the inscription "Cereri Ferdinandea Sacrum," and below stood the verse (in French) taken from the monthly "Correspondenz," evidence that Gauss in all good humor recalled those individuals who once felt qualified to make sport of his scientific performance. In the book set down most precisely in thousands of figures, are the calculations of the different orbits worked out for Ceres and comparisons with the calculations of Olbers, Zach and others.

Through the unexpected rediscovery of Ceres the astronomers of that time were inspired with fresh zeal. New discoveries followed fast on the heels of one another.

On March 28, 1802, Olbers found another grain of sand in space, the planet Pallas. Its orbit was immediately calculated by Gauss, and presently this planet came to be Gauss' "favorite", inasmuch as he devoted years of investigation and voluminous calculations to its deviations. Once in 1832 we saw and handled a manuscript dealing with this subject and labelled "ready for the press". But since then almost a quarter-century has slipped by without astronomers having had further word of it. Without doubt these pioneer calculations are now lying by, put to one side with those of Ceres.

In 1810 Gauss received from the Institute of France a new distinction, the medal established by M. Lalande for the best work or the most novel astronomical observation. This came to him for his work on Pallas. He chose however to have a watch sent him from Paris in place of the more costly medal, and in arranging this was aided by the Secretary of the Institute and by Mlle. Sophie Germain.* Many creative hours of the richest period of his life and many hours of pain in his last illness he counted off on this time-piece, from that time till it stopped at the hour of his death a month ago.

Early in the new century the government of Hannover had intended to build for Goettingen a new Observatory provided with the best possible equipment and to entrust its direction to Professor Seyffer. Now suddenly Gauss' name was heard as one of the most eminent in astronomy. The kind and alert Olbers is perhaps the one chiefly to be thanked that a few years later Gauss was called to our University, to its glory and fame.

* Gauss had carried on a scientific correspondence with her since 1804, knowing her only as LeBlanc. Not till 1807, thru' Denon, did he learn her real name.

Olbers had learned in confidence that Gauss had received from the Russian government a call to Petersburg under very advantageous conditions. Gauss had sought Olbers' advice on this. Olbers was therefore moved both by the fear of losing Gauss for Germany and by his wish to win for him a suitable sphere of activity in the Fatherland.

Gauss had never intimated to Olbers any desire to come to Goettingen, nor was there any mention in the letters that passed between them of the building of the Observatory. But Olbers saw in Gauss so lofty a mind and so completely the right personality for directing the future Observatory that he immediately thought to avail himself of the existing situation to secure Gauss for Goettingen. He therefore asked Gauss' permission, without explaining his reasons, to tell a friend under promise of strictest secrecy of the Petersburg call. He then wrote to Heeren in Goettingen as follows, warmly recommending Gauss:

"Pardon me, my respected friend, that I trespass on your limited time. Only love of science and patriotism (if I may call it that) for Goettingen move me to this importunity. Yet it may be pardoned since you asked me when you were here in Bremen to give you my thoughts on the choice of a director for the Observatory soon to be built in Goettingen.

"I assume that it is still the intention not to entrust this position to Professor Seyffer who will always be merely a professor of astronomy, also that no definite choice has yet been made, a choice which I said as we talked together was not an easy one. But just now I see a possibility of presently filling this position in a very exceptional way, and if my idea is to be considered it must be presented without delay.

"You know, my dear friend, although mathematics and astronomy are not your field, of the great fame which has come to Dr. Gauss of Braunschweig. The fame is fully merited, for this young man of twenty-five years is already ahead of all his mathematical contemporaries. I consider myself in some measure qualified to express this judgment since I have not only read all he has written, but have been in confidential correspondence with him since the first of the year. I have been moved to highest admiration by his knowledge, his extraordinary prowess in analytical and astronomical calculation, his unwearied activity and industry, his quite incomparable genius. And in our correspondence the further he has gone in communicating his thought, the higher my admiration has risen. Moreover the science of astronomy, and preferably practical astronomy, is particularly close to his heart, though thus far he has had little opportunity for the latter because of lack of instruments. He is wholly averse to any position as teacher of mathematics. His heart's desire is to be astronomer in some observatory where he could divide his time between observation and close, profound research for the advancement of science.

"Is not this just the man who would fit into the future opening at Goettingen in any capacity? I can testify on my honor that never has there been even any mention of the observatory at Goettingen.

"I give you now the picture and immediate cause for this letter. Germany is in danger of losing this distinguished scientist. Under date of October 12 Dr. Gauss informed me in strictest confidence that he had received from Petersburg the offer of the position of astronomer and director of the observatory there, but was undecided as to whether he should accept this call, which in many respects is very pleasing to him. He asked my advice on the matter. In my reply I asked him to postpone any

acceptance and meanwhile to permit me to communicate the offer to a friend on whose discretion he could rely. Yesterday I received his permission, and I make immediate use of it to inform you of the circumstances. If it should be desired, or if it is possible to give consideration to Dr. Gauss, quick action must be taken.

"I trust wholly to your judgment and discernment as to how valuable this would be for Goettingen. Only I ask you in any case to consider this letter and its contents as matters brought to you as a friend and in strictest confidence.

"Yet I must repeat that I see it as important for the glory of 'Georgia Augusta' to secure a man who is already admired by all Europe.

"It will be a great favor, dear friend, if you can let me have some word on this matter as soon as possible. Pardon this very unorganized, perhaps hardly intelligible letter, which has been written in great haste and with constant interruptions.

"With--as you know--feelings of sincerest attachment and respect,

I am ever yours

W. Olbers"

Bremen, November 3, 1802

The answer showed that the proposal met' a most favorable reception, though there would still be some unavoidable delay with the matter. Olbers communicated this to Gauss who up to this time was in complete ignorance of the steps taken.

Gauss now decided to await further developments and to decline the Petersburg offer. Moreover he felt himself obligated by sincere gratitude to his noble benefactor Duke Carl Wilhelm Ferdinand, who had just approved a salary increase for his scientific work in Braunschweig, where also the building of an observatory was in prospect.

Now that the discussions with Petersburg were at an end and the University Senate had had its attention directed to Gauss, there would have been an immediate call to Goettingen had not the close relationship of Gauss to the Duke of Braunschweig made this impractical. The University Regents kept Gauss in sight however and seized the first opportunity to appoint him.

The mutual desire of Gauss and Olbers to know each other personally came as a natural result of their close correspondence, begun with a letter from Gauss dated January 18, 1801. On June 22, 1802, Gauss took his first trip to Bremen. Here he spent three weeks in Olbers' home, during which time they went to Lilienthal to spend two days of rare enjoyment with Schröter.

An excellent portrait painter, Schwartz, who was then in Bremen, did a pastel portrait of Gauss at this time, the only youthful one in existence. This was said to be a speaking likeness and has remained in possession of the Olbers family. Soon afterwards Gauss received an equally successful portrait of Olbers, executed by the same artist, and dear to him as long as he lived. After his death it passed into the hands of Gauss' trusted physician and Olbers' great admirer, Professor Baum.

It was at this time that Olbers first mentioned to Gauss a young man by the name of Bessel, with whom he had become acquainted at the Kulenkamp counting-house,

and who zealously spent his free time and even his nights on astronomy, showing a marked gift for it.

Gauss did not meet Bessel personally during this first visit to Bremen, but soon there developed between the two astronomers a close association brought about by Olbers and by Gauss' investigations of the Pallas deviations. This continued for forty-two years and worked an infinite blessing to the development of astronomy.

On July 15th, just returned from Bremen to Braunschweig, Gauss was met with another invitation. Zach invited him, that they might become better acquainted, to join him on the Brocken--a short, delightful trip--where Zach was to spend fourteen days, to give powder signals from there. On August 28th Gauss joined him and some days later went with him to Gotha, where Gauss remained till December 7th, part of the time staying with Zach at the Seeberger Observatory.

The following year he saw his good friend Olbers again at Bad Rehburg near Hannover. Olbers wrote him on July 6th, 1804: "The first of August I go to Rehburg for fourteen days. In one day you could get there from Braunschweig. What a delight for me if your good angel were to inspire you to seek refreshment in this romantically lovely place at just that time!"

The deep enjoyment Gauss experienced in these three short trips stood out to the end of his life as among the happiest memories of his youth. The more, since those years covered the particularly rich period in which not only his great mental achievements were crowned with fame, but in which also his sensitive spirit received its richest inspiration.

From 1803 Gauss and Johanna Osthof of Braunschweig had come to know each other better and better, and on November 22, 1804, they became engaged. Three days later a letter Gauss wrote to his friend Bolyai contained the happy words: "Life stands before me like eternal spring, in new and shining colors."

On October 9, 1805, they were married and experienced in their marriage the fullest, most unmarred happiness. Of this marriage three children were born: the oldest son Joseph (Ober-Baurath in Hannover), born in Braunschweig August 21, 1806; Minna (later married to Prof. Ewald) born in Goettingen February 29, 1808, died at Tübingen August 12, 1840; Louis, born at Goettingen September 10, 1809, died March 1, 1810. Following this last birth Gauss lost his beloved wife on October 11, 1809

While Gauss was living a quiet family life in Braunschweig and was hastening from one great achievement to another, inspired by the creative forces of youth, there was drawing closer that disastrous time which subjected our Fatherland to a bitter fate.

Napoleon's power had already fastened itself upon western Germany. And though the worst was to be feared from the encroachments of the enemy, still no defense agreement could be reached between Prussia and Austria. In the face of an ever more confused and threatening situation, on January 30, 1806, the Duke of Braunschweig was entrusted by the Court at Berlin with a diplomatic mission to St. Petersburg which seems to have achieved no results. In Petersburg however he was approached several times on the subject of the gifted young astronomer, and to use his own words, "they dropped a word" in his ear to approve Gauss' call to the Petersburg Academy.

The Duke, definitely turning down this suggestion, was again in Braunschweig by March 24, when he bettered Gauss' position by an increase in salary announced to him on his birthday, April 30th. It was on this occasion that both men saw each other for the last time. Soon death had dissolved the relationship which had lasted for fourteen years of mutual respect and esteem.

The battle of Austerlitz was fought. Prussia stood deserted and was forced to take up alone the unequal struggle against the Emperor of France. Napoleon's army early in October, 1806, rolled on through the Frankland towards the river Saale: the battles of Auerstedt and Jena were fought by Duke Carl Wilhelm Ferdinand and were lost, and the Duke himself was fatally wounded and brought back to Braunschweig.

It was decided immediately to send a deputation to Napoleon who was then in Halle, to ask mercy for the sorely wounded commander, with permission for the unhappy old Duke to die by his own fireside. The deputation was rudely repulsed, with derision for the Duke's poor military leadership. With nothing accomplished the deputation then turned back and took steps to save the unhappy commander from disgraceful captivity.

On a morning late in the fall Gauss, then living on the Steinweg, saw a big ambulance drawn by a pair of horses pass out the gate of the Castle garden and move towards Braunschweig's Wenden Gate. In the ambulance lay the sorely wounded Duke on his flight to Altona. Gauss watched with deep emotion the departure of this friend who had done for him what a father might well have done. He said little but was deeply moved. After some days of travel the dying Duke reached Altona, and here in a small house in Ottensen he died, not far from that linden tree which shaded the grave of a great German poet.

So ended the life of this noble prince, doomed to go down in German history as one of those blamed for the defeats of Jena and Auerstedt, responsible for the most disastrous years of our Fatherland's history. But his noble heart which considered always the good of his country and the well-being of his subjects, had been rewarded. For in future millennia in which Napoleon's victories will be as good as forgotten a net of telegraph wires will encircle the globe, man will build a new civilization on the basis of mathematics, astronomy and the natural sciences, and close to the name of Gauss who celebrated Germany's victories of the Spirit will stand the name of his patron, Duke Carl Wilhelm Ferdinand, filling an honorable place in the history of Science. Zach wrote Gauss in a letter dated January 27, 1803: "You will see to it that his great name is inscribed on the Heavens."

In that gloomy year when the enemy poured over Germany from the Rhine to the Niemen, Gauss lived on for some months with his little family in the city of his birth, criticized by many and perhaps even envied for his independent attitude. Then at last there came to him the call to Goettingen which was the turning point in his life. Discussion of it had never been wholly dropped, had been often resumed, but the right moment for a definite decision had never been found. How much they had counted however on securing Gauss for Goettingen comes out in a letter from Heyne to Olbers, dated Sept. 26, 1804. We quote the following excerpt:

"I am infinitely grateful to you~~A~~ for your interest in helping Georgia Augusta and for your kind mediation in the matter so close to our hearts, of securing Dr. Gauss. Thought has been given to an adequate salary and this should present no difficulties. Greater difficulties are to be met in Gauss' relations with his Duke. Likewise the building of the observatory is halted, though a start will presently be made. So at the moment in fact there would be only labor in vain for Gauss. I can give you assurance from Hannover, however, that the position stands open for Gauss and will remain so. What you say of our Gauss as a

man is precisely what enhances his greatness as mathematician and astronomer."

After the unfortunate results of the battle at Jena all conditions in Braunschweig were so completely changed that fresh attempts were made by Petersburg to reopen negotiations. These were reason for Hannover's taking prompt steps to prevent the loss of Gauss to Germany. Several men of vision, among them Brandes, former Curator, again exerted themselves to secure Gauss as Director of the Observatory, and this time they met with success.

Gauss received the call in 1807 while on a visit to Olbers and accepted it, first counseling with his old friend. On his return journey from Bremen he visited Brandes in Hannover and there made Rehburg's acquaintance. On November 21st of the same year he came to Goettingen to assume his position.

As matters stood our country was then occupied by the enemy, although there were certain authorities which kept in touch with the London Chancellory. Gauss was installed by the Hannoverian government. By the time he entered upon his work however, this was in complete dissolution and the new Westphalian government was not yet organized. In this confusion the matter of swearing Gauss into office was forgotten and he remained all his life exempt from this formality.

The first years of Gauss' residence in Goettingen were troubled ones in a number of ways. He was in material need, was oppressed by many unhappy events. Yet held himself only the more closely to his science. It was at this time that he lost his father, and two years later, on October 11, 1809, death took from him the beloved wife with whom he had had such complete happiness.

Also there were many annoyances connected with his position. He had hardly more than settled here and had as yet drawn no salary when Napoleon's order was issued for a huge contribution to the war, a forced levy for the new Kingdom of Westphalia. For our University this burden was divided according to position and Gauss' share was set at two thousand francs.

For Gauss it was all but impossible to meet this oppressive levy. Then one day he received the full sum from Olbers, with a kind letter expressing regret that men of learning should be subject to such shameful exactions. But Gauss could not bring himself to accept the money and returned it forthwith, though deeply grateful for his friend's high-minded generosity. Shortly afterwards he received another letter from Laplace, telling him that Laplace had already paid in for him in Paris the two thousand francs demanded. Again Gauss felt obliged to decline this kind offer and presently returned to the great French mathematician the full sum of the obligation with interest for the time elapsed. We would not go into the matter in such detail but for the light it sheds on Gauss' character and for the fact that some incorrect reports of the matter received wide circulation.

Nevertheless it seemed meant that his difficult situation was not to be ignored. Soon after declining the help of all friends he received from Frankfort an anonymous gift of one thousand guilders which he later learned was a gift from the Crown Prince. Also Friedrich Perthes, who of course had other connections with Gauss, proved during these hard times to be so thoughtful that Gauss commemorated him with warm gratitude when Perthes' biography was published by his son some years ago. Towards the expense of this Gauss had been able to make "a friendly contribution," to use his own words.

Gauss was occupied during the first part of his residence in Goettingen with the publication of his immortal work: "Theoria motus corporum coelestium in sectionibus conicis solem ambientium." This was at first written in German, but Perthes (the publisher), wishing to reach a wider public, wanted it published in French. Gauss' political feelings would not permit this, but he decided, in order so far as possible to satisfy Perthes, to publish the work in Latin. In this language it appeared therefore in 1809, with an introduction written on March 28th; as it happened, just two hundred years later, almost to the day, than Kepler's Praefatio de Stella Martis.

On the foundation of Newton's Law of Gravitation or of Kepler's Laws inductively arrived at and known to be implicit in that general law, Gauss develops in his Theoria methods by which the orbit of every heavenly body of our solar system may be determined in the surest and simplest way from the necessary observations, and without any further hypothesis as to their nature.

This new theory, as has already been said, found its confirmation in 1801 when it was applied with amazing success to the planet Ceres discovered by Piazzi. This led to its largely supplanting all other methods in use since Newton's time for calculating the orbits of the heavenly bodies.

It is known that the calculation of the paths of comets presented the earlier astronomers with much greater difficulties than the calculations of the five major planets of our solar system as investigated by Kepler.

Remarkably enough Gauss already in 1795, at the end of his eighteenth year was using the method of least

squares. We cannot doubt that practical need as well as the study of nature led him to this epoch-making discovery. He has often said to us that the solution of this problem was very plain since the question before him was that of combining a system of observations according to the most logical principle. He had supposed that others, and certainly Tobias Mayer, were in possession of this method. He had therefore gone through the great astronomer's handwritten manuscripts in the Goettingen Library, but unfortunately his search revealed nothing.

It is known that in 1806 Legendre had likewise been led to the method of least squares in his work Nouvelles Méthodes pour la détermination des orbites des comètes and that for this reason French claims to priority were raised, for the Theoria Motus appeared almost three years later. Since Gauss had communicated this important discovery which he made in 1795 in the following year to his friend Bolyai, Bolyai is the only man now living who can give both scientific and contemporary testimony. In the beginning of the century Gauss acquainted Olbers and also a friend in South Germany with the method of least squares, though only in the Theoria Motus was it given to the public. In mentioning the dispute he once said to us: "The method of least squares is not the greatest of my discoveries". Another time in the presence of other listeners he said only: "They should have felt they could believe me."

The appearance of the Theoria Motus arrested universal attention among scientists, receiving the recognition and admiration it merited. The Crown Prince who had so warmly interested himself in Gauss sent him a gold medal. Another was sent him by the Royal Society of London. Honors from learned societies in all parts of the world came to him. Even the enemy who occupied our country sent

his token of high esteem. It is typical of Gauss that in this time of Germany's humiliation he proved himself so loyal a German, opposing the foreign conqueror and guarding the treasures of our literature and science with the full force of his giant spirit. With Napoleon's predilection for mathematics, with the admiration Laplace expressed for him, how easy it would have been for him to attain to high place, high distinctions and material advantages! But he sought no such harvests. The fulfilment of his scientific calling provided him his happiness and his goal in life.

The French had meanwhile settled down in Germany and so comfortably that they seemed indeed to have little desire to turn their backs on us in any near future. It was therefore to their interest not to slight the government's University in the Kingdom of Westphalia. For this reason Gauss was subjected to no further annoyances.

Before Gauss came to Goettingen but little was accomplished in the field of practical astronomy. This in common with theoretical astronomy was entering a new phase with the coming of the new century. Of the new Observatory there were only the foundations and there was little prospect under existing conditions that the building would go forward quickly.

For the time being therefore Gauss continued his observations at the old Observatory where Tobias Mayer had been so active and had accomplished so much. It was located in an old slate-roofed tower which had served in the Middle Ages to protect the inner city wall. It is now in ruins and can be recognized only by its foundations.

Finally in 1810, after long interruption, construction of the new Observatory was resumed by the Wesphalian Government and there was set aside for the completion of the building the sum of 200,000 francs, to be spread over five years. Various architects worked on the plans under the direction of the church-architect Müller, and at last it was erected in Doric style, in essentials according to the ideas of the astronomers.

The painful loneliness which the death of his first wife in October of 1809 brought Gauss proved a desolating experience. He was a sensitive man, of warm and deep feeling, a man who turned to the small, simple pleasures in his hours of leisure, just as at other times he was absorbed by his mental labors. Anxiety over his small motherless children oppressed him. He saw their need of a mother and the conviction grew in him that in such a second marriage the choice involved would be guided by his dead wife's judgment. Soon his decision was made to take the step.

On April 1, 1810, he became engaged to Minna Waldeck, daughter of Hofrath Waldeck* and beloved friend of his first wife. On August 4th of the same year they were married. His two younger sons and his youngest daughter, all still living, were the issue of this marriage.

This happy re-establishment of his home in Goettingen served to tie him here more definitely and confirmed his resolve to decline a call to the Royal Academy of Science in Berlin which had come to him in April

* Professor of Law at Goettingen University.

through Wilhelm von Humboldt. At first Gauss had hesitated to decline, since in Berlin he would have been free of the teaching involved in a professorship. This was always a burden to him, as much then as in later years, since he was reluctant to give it the time which was so precious to him. Nevertheless he performed as teacher a service as richly rewarding to science as was everything else he undertook. In a higher sense also this labor was richly repaid by the many close bonds of friendship now cemented for life. For soon there gathered around him, though he had not lived long in Goettingen, a circle of scholars who ever afterward treasured his memory in their hearts. In the earliest years, as early as 1808, we call to mind first of all the now deceased Schumacher, publisher for so many years of the Astronomical News and later Director of the Altona Observatory. Up to his death in 1850 he remained in close touch with Gauss and in active and uninterrupted correspondence. In this was doubtless much news of scientific as well as of biographical importance.

Then in 1810, came Gerling, and soon thereafter Nicolai, Möbius, Struve and Encke, subsequently the Directors of the Observatories of Mannheim, Leipzig, Pulkowa and Berlin. Several of these were still studying here in the year 1813, and only in that troubled time did they leave their studies, Hanbury to prove himself on the battlefield.

Gauss was soon in touch, either by correspondence or in person, with a wider circle of the most distinguished European scholars; with Olbers and Zach, both close friends from the time of the discovery of Ceres; with Piazzini, who was god-father to his oldest son Joseph, and with whom he was in active correspondence. With Lindenau,

Laplace, Alexander v. Humboldt, Herschel and others a closer relationship developed later.

Meanwhile to the joy and surprise of the astronomers the great comet of 1811 had unexpectedly appeared in the Heavens. It was seen by Gauss for the first time in the late twilight of August 22. Close observations had to be postponed, partly because of clouds, partly because the view from the north side of the old Observatory was too restricted by city buildings. But already, early in August when Zach's observations first arrived Gauss had calculated from partial data the parabolic elements of the comet and had thus pre-determined its course in a way fully verified by the appearance of the comet itself. Likewise he predicted its much more brilliant appearance as it moved away from the sun. The nations of Europe saw in it only a divine rod of wrath, a prelude to the burning of Moscow, a sign of the overthrow of Napoleon whose great army soon lay buried in the ice-fields of Smolensk and on the Beresina.

At once Germany leaped to arms, and our friends the Cossacks, for whom one could not but feel great sympathy, were close behind. One of their officers was naive enough, after he had been shown the Observatory by Gauss, to ask for its only chronometer, one presented to it as a souvenir by King Jerome.

With Napoleon's power overthrown and former conditions restored, Gauss enjoyed the continuous good-will of our Kings and of the University Senate. The new Observatory which the new Westphalian government had begun was soon finished so far as essentials went, and in the fall of 1816 the Director moved in.

For instruments there were those in use in the old Observatory, including the big Bird'sche wallquadrant (now obsolete), and also, coming from Lilienthal, a number of mostly useless telescopes with which little could be done. First of all then, at Gerling's instigation a new meridian-circle was procured from the senior Repsold.

Soon afterwards, in April of 1816, Gauss with his ten-year old son and Dr. Tittels as companions undertook a journey to München and Benedictbeuern in order to become better acquainted with the firm of Reichenbachs and Frauenhofers, Utzschneiders and Ertels. From these unexcelled makers Gauss meant to order two new meridian instruments of the best design, after discussing the details of their construction.

Gauss went by way of Gotha, where he stopped over some days to visit Lindenau at the Seeberg Observatory. The heaviness of the Goettingen coach in which they were travelling had annoyed him, and he gladly accepted Lindenau's friendly offer of his own comfortable coach for continuing the journey. We take a short report of the journey from a letter home which he wrote in Munich on Friday, April 26th.

"Yesterday evening about 8 o'clock we arrived here in good shapeNow first of all a little account of the trip. On Sunday, early, we left Seeberg in Lindenau's coach and with horses we hired, to drive through the Thuringian Forest where the roads were still completely covered with ice. In summer this region must be romantically beautiful. These horses brought us the seven miles to Meinungen, where we immediately took post-horses for the all night drive over the fine Bavarian highway. The horses flew swift as birds and we

reached Würzburg next morning. We were rather weary, but were refreshed by a mid-day meal. As night approached we continued on our way, again to drive all night and into the next day as far as Augsburg, where we spent the night. Thursday morning we looked around a little and by mid-day were again on our way. These last eight and a half miles over an indescribable road took seven and a half hours. And so we came yesterday to beautiful Munich.

I was myself rather exhausted by the journey, but rest has set all right again and today I feel as well as in Goettingen. We are lodged in a very good inn.

Early this morning Reichenbach came to see me, having already learned of my arrival. I have spent the greater part of the day with him and have accepted his very friendly and urgent invitation to stay in his home. Tomorrow we will move there, also Tittels.....Utzschneider too I have become acquainted with, and on Tuesday we will go with him to his estate in Benedictbeuern on the Tyrolean border. Reichenbach is a very gracious man who overwhelms me with kindness; his home is in the suburbs, has an extremely pleasant location and bears the stamp of great affluence."

A second letter, headed: "Reichenhall, 36 hours beyond Munich. Sunday evening, May 11, 1816" contains the account of the return journey:

"At last I am on my way home. After twelve very pleasant days in Munich, in which I include the trip to Benedictbeuern, I have come this far with Reichenbach who had to come here on business. After seeing something of this vicinity and the nearby Berchtesgaden, as well as

the extremely interesting salt-mines and the incomparably beautiful region, tomorrow will find me on my way back to Goettingen. We do not return to Munich, but take the nearer way to Regensburg and Nürnberg, then Gotha for a couple of days. . . . I write this at midnight with my eyes almost closing, since today we made the excursion to Berchtesgaden, and there in the underground salt-mines we were constantly on the move"

The new meridian instruments which arrived here in 1819 and 1821, also an excellent clock from Hardy in London, a gift from the Earl of Sussex, were put to efficient use under Gauss' skilled hand and have since given valued service.

During this period Gauss gave himself chiefly to theoretical and practical astronomy. He gave himself no rest, day or night. No exertion of mind or body seemed too great for him in carrying through a series of tasks. This labor was destined to reorient 19th Century science and to broaden its foundations in ways the soundness of which will be recognized and evaluated only by future generations.

Gauss linked astronomy very closely with geodesy, a science which till now had been scarcely more than land-surveying. He soon felt the call to work in this new field, and in a short time had carried it forward to an original and illustrious eminence which puts it today in the group of the loftiest of the sciences.

It was in the summer of 1819 that Schumacher and Gauss met in Lauenburg to begin observations with the Ramsden zenith-sector which the English government had put at their disposal. The Danish government had already commissioned Schumacher to make a base measurement

and a triangulation of the Duchy of Schleswig-Holstein, to which were to be attached longitudinal measurements to the south. This zenith-sector, brought to Goettingen in 1827, later was destroyed by fire in the Tower of London, in 1845 if we remember correctly.

During Gauss' stay in Lauenburg there appeared again a brilliant comet which he stated was one of the most remarkable on record, for in the summer of 1819 the earth found itself within its tail. Gauss thought it probable that it exercised a certain influence on our atmosphere, for after very sultry and oppressive air conditions there followed a thunderstorm of greater violence than any other he could recall in his lifetime.

Through the influence and the strong scientific bent of the Count of Münster the necessary means were readily provided for the geodetic survey of Hannover, to be executed by Gauss between Goettingen and Altona. This work was accomplished between 1821 and 1824 and is in theory as well as in practical execution to be ranked with Gauss' most memorable achievements.

A geodetic survey we know falls into two parts. On the astronomical side is the ascertaining of the geographical measurement between the two extremities, and on the geodetic side is the joining of these by a trigonometrical network. In this undertaking the astronomical observations present comparatively few difficulties. With the help of the zenith-sector mentioned above and the two Reichenbach meridian circles for control, these were announced by Gauss in 1828.

Very much more complicated are the geodetic operations worked out between the two end-points. For this Gauss

devised new and original methods. Working from the principle of choosing for the uniting triangle sides as long as possible, he soon discovered that with ordinary means in a distance from five to fifteen miles the end-points of the triangle sides either could not be seen at all, or could be made visible only with great difficulty and with none of the needed distinctness. In the great French geodetic survey between Dunkirk and Formentera argand lamps had therefore been used, provided with reflectors similar to those used on light-houses. These had however soon proved unsuitable and impractical for the purpose. First, one was obliged to work at night, which involved many inconveniences. Next, it was generally extremely difficult to discern such a light from a great distance. For this reason there are recorded some very astonishing data. In short the whole arrangement proved to be inexact and extremely costly.

Gauss quickly recognized all these faults and replaced the artificial night-light with his simple, cheap, infinitely more powerful and efficient heliotrope, an instrument consisting of a telescope and two small plane-mirrors mounted at right angles to each other. With this it is possible with great accuracy to direct sunlight, reflected by one mirror, to a point many miles away. Across the miles this light resembles a brilliant star fixed on top of a mountain or a tower. This simple but very ingenious instrument, variously altered in the course of time partly by Gauss, partly by others, has proved so useful for all triangulations that it is in universal use today. In the field of experiment the heliotrope was Gauss' "pet" discovery, arrived at by straight thinking he said, and not--as some claimed--by a happy accident. It might well be that he saw a window-pane on the Michaelis tower in Lüneburg illuminated by a pane on a Hamburg tower, but long before that he had his invention clearly in mind.

Following this discovery Gauss threw out the question, half in earnest, half in jest, of whether the moon might be inhabited by a more intelligent race. Admitting this was not very probable in view of his observations of our nearer planets, he suggested that the heliotrope might help to establish safe telegraphic communication between the two worlds, and without exorbitant cost. He is said even to have calculated the size of the mirrors needed and to have reached a very satisfactory result. "This would be a discovery even greater than that of America", he said, "if we could get in touch with our neighbors on the moon."

With the help of the heliotrope this great Hannover triangle between the Brocken, the Inselsberg and the Hohenhagen--perhaps the greatest yet measured--was measured so exactly that the sum of the three angles differed by only about two-tenths of a second from the two right-angles. It is indeed not only the quite unprecedented accuracy (for that day) of the observations which distinguished this triangulation, but the insight with which Gauss assembled the measurements into a completely integrated result. We may therefore say in conclusion that Gauss simultaneously devised new methods for (1) projecting on a plane the points of the surface of the elliptic spheroid of our earth; (2) comparing widely separated systems of triangles according to the laws of probability which were set forth in his Supplementum Theoriae Combinationis Observationum.

Not seldom in these investigations one stumbles on tasks of such magnitude and difficulty that only a mind such as his could penetrate and solve them. Intimations of the methods he used but never published are to be found now and again amidst other material in Paragraph 22 of the writing just named.

In the years following the completion of this survey and triangulation it was Gauss' intention to publish a comprehensive volume on geodesy, in which these surveys would be included as examples to clarify his theory. He said as much to us and also wrote to this effect to Pfaff, but unfortunately this plan was never carried through. Instead there appeared later, in 1847 and 1848, when the great man saw the compass of his life growing narrower and narrower, two articles in the publication of the Royal Academy of Science: "Investigations into Problems of Higher Geodesy". All remaining material, namely the detail of the Hannoverian Survey, is preserved with his scientific legacy, awaiting future publication.

It is not possible to give to a wide circle any idea of the profundity of these geodetic investigations nor of the scope of both the practical execution and the numerical calculations involved. Only those who, like the author of these pages, have themselves experimented in such matters, can fully evaluate such prodigious achievements. In fact even the initiated stand amazed that a single head, a single hand, could have mastered alone and unaided and in such comparatively short time, such a gigantic piece of calculation.

As the keystone of this geodetic task there stands a determination of co-ordinates for some 3000 points of the Hannoverian countryside, in which every pair of numbers is the result of an extended calculation resting on the method of least squares. For the carrying out of each of these a less practised calculator would have needed perhaps several days.

At this point in our task it seems proper to throw a clearer light on the proposed calling of Gauss to Berlin by the Prussian government, concerning which none too fair

reports were circulated. These showed Gauss' sincere, scrupulously upright character in a most unfavorable light. This proposed call to Berlin which never definitely materialized was promoted by General von Müffling with Herr von Lindenau serving as friendly go-between. The situation is completely revealed in a series of letters from von Müffling and Lindenau to Gauss which we have in our possession; and also in the reports of the Royal University Senate at Hannover, which are put at our disposal.

We give here brief excerpts from these documents. In the first letter from von Müffling, headed Berlin, April 14, 1821, there is expressed merely the wish to secure Gauss for Berlin. On November 15 of the same year Müffling in Berlin writes to Lindenau, and the latter communicates to Gauss the following from Müffling's letter:

"The Minister von Altenstein has informed me that the business concerning Gauss has prospered so far that he needs to know Gauss' terms in order to report to the King on the matter. Gauss does not want the position of ordinary University Professor, and Altenstein is agreed to that. He shall not be bothered with daily routines, provided that he does not refuse to give to very promising young men the final polishing and opportunity for development. Altenstein has especially in mind that Gauss should work to brighten again the dimming lustre of a once glorious Academy, something Gauss of all men could do. Altenstein wished to report to the King by New Year's at latest, and the affair will meet with no difficulties if Gauss asks not over 2000 thaler. Gauss could then enter on his new position here towards Easter."

Lindenau then recommends to Gauss the new position in Berlin, asks him to take it under consideration and to

communicate his decision either to him or to Müffling. At the end of a letter from Lindenau written from Gotha July 18, 1822, we find only this: "From Berlin nothing more has reached me concerning the business in hand."

In Lindenau's next letter to Gauss dated Gotha, January 6, 1823, he expresses regret that the Survey was taking so much time from Gauss' scientific investigations and continues: "This brings me to the business begun with Berlin. In Berlin I believe you would be completely master of your own time, as the interests of science require. A few weeks ago I spoke with General Müffling on this matter. He felt not a moment's doubt of the King's compliance with your terms and only wanted me to give him early information as to whether the transfer to Berlin still was in your plans and when you could go. Through Tralles' death every obstacle which might have arisen is removed."

There follows then a letter from Müffling dated April 1, 1823, saying: "Gauss is now proposed by the Academy of Science to the King for Tralles' position, in addition to two others, Pfaff, and Bessel. But the salary, covering also the secretaryship, is a matter of only about 1200 thaler. Minister Altenstein, with whom everything moves slowly, has asked me to support him with the King in asking for the balance. Quite briefly but most urgently I represented the need, thus coming back to my old project of a Polytechnic School which Alexander von Humboldt has also been urging. Incidentally I have learned definitely that our German philologists are just as intolerant as are the Jesuits, and that a real conspiracy exists to keep down the mathematicians. I hope the Gauss business now at last comes off, and when he is once here that I find in him a pillar for raising aloft the mathematics of our country."

This letter was forwarded by Lindenau to Gauss on April 29, 1823, with a note from which we take the following: "The enclosed letter from Muffling I wanted to bring to you personally in order to speak further with you about it. But circumstances have made that impossible. It is the prescribed procedure that you were proposed not alone, but with Pfaff and Bessel. But that you will be preferred and also probably all your conditions agreed to, is reasonably to be expected, though at this time we cannot be sure. That there is beginning to be talk about it in public is not surprising, since in Berlin no secret is made of anything proposed to the King. I am writing Muffling today in order to hasten a definite decision, and if an official offer follows, it remains for you to decide whether to accept it or the improved conditions in Hannover. It is hard to advise since the choice depends on one's individual situation, and in recent years I have been too unacquainted with your home and personal life to judge understandingly between the advantages of life for you in Berlin or in Goettingen. For your intellectual labors Berlin would seem to me more favorable.

"If it is possible it would be better for you to defer your visit to Hannover until you have Muffling's next letter, since out of it may come more perplexities. But if you should be obliged to go to Hannover sooner, and should be asked by the authorities there if you have received a call to Berlin, it would in my opinion be completely truthful as well as wise to reply that you have indeed been informed by friends of the intention of the Royal Prussian Government to offer you a place in the Academy, without yet having received any proposal yourself. This would perhaps give you an opportunity to learn Hannover's inclination as to your advancement, and thus enable you to decide which life offers more advantages."

Then came two letters from Lindenau dated July 2 and October 21, 1823, in which only brief mention is made of the expected call. In the first we find: "Muffling is beside himself over the long delay of the business which should have been settled long since, but definitely hopes that surely within a few weeks the matter will be settled." In the second we find: "That no further news comes from Berlin is to me incredible, since General Muffling way back in June considered the matter settled."

After more than a year had again elapsed and nothing further had come from Berlin, Gauss--with his Survey finished--went in the end of October, 1824, to Hannover, visited the Privy Councillor of the Cabinet, Hoppenstedt, and told him of the Prussian Government's proposal to call him. A month later Hoppenstedt brought the matter before the University Senate, having requested Gauss to put his terms in writing, which he did in a letter dated November 4. By December 11th Gauss received the announcement from Hoppenstedt that all his conditions were accepted, and on December 17th he received the final papers from London.

In the meantime, between Nov. 4 and Dec. 11, Lindenau forwarded to Gauss a note of Muffling's (of Nov. 28) in which the latter set down in detail the conditions which it was thought Gauss made for Berlin. These however were completely different from those which Gauss himself had made, for Gauss had put first the securing of free time for his scientific investigations. Gauss' request for free residence was ignored, besides which there was required the taking over of the Academy's secretaryship as well as the business of its administration, conditions quite exceeding Gauss' terms. Muffling writes in this letter: "Now the question is: is Gauss of a mind to accept the position, and on the terms here set forth?"

Lindenau noted further: "As for the forms to be observed, I suppose that once you have definitely and irrevocably made up your mind to leave Goettingen, you would need to request an official call from Berlin and then ask for release from Hannover."

Gauss now turned down the call to Berlin, since the obligations involved would have worked a disadvantage to his scientific work, and the Hannoverian government immediately met all his wishes.

The presentation of these facts makes it definitely clear that Gauss had in no way obligated himself to the Prussian government, and that no definite call ever came to him. He was therefore free to accept or decline as seemed best. He had moreover promised Hannover to accept Berlin's call only after Hannover's last efforts had failed. Our University may thank the vision and the quick and business-like methods of our Council and above all the scientific and enlightened mind of the Earl of Münster, that Gauss' great name has gone beyond her own.

Some months later a last attempt was made by Bessel to secure Gauss for Berlin. "As for Gauss," writes Bessel to Olbers March 6, 1825, "I have made still a last effort, though with no hope of succeeding. I can't penetrate the mystery which lies over this affair, but I believe a tricky negotiator has spoiled it. If this is the case, perhaps it could still be straightened out if one went at it openly. I have asked Gauss if he will not authorize me to arrange matters with Berlin by word of mouth. I fear it is too late, but I await his reply with impatience."

Gauss decided not to sever his connection with Goettingen, and writes Pfaff: "I am now bound for life

to Goettingen, unforeseen circumstances excepted. Not by formal promises, to be sure, but by the bonds of very sincere gratitude for our Government's very liberal attitude. My affair might well have taken another turn but for several fortuitous occurrences."

In the fall of 1828 Gauss decided to accept the friendly invitation of Alexander von Humboldt to spend some days with him in Berlin during the Berlin Exhibition of Natural Sciences. Here he became acquainted with Wilhelm Weber, an acquaintance which led to Weber's call to Goettingen when the chair of physics was vacated by the death of Tobias Mayer.

Now that the survey and triangulation were completed, work which had claimed Gauss' time for so long, there appeared almost yearly one or more treatises in the Goettingen Society's publication, some arithmetical in content, some geodetic, some physical. In 1831 he was suddenly seized by a great fancy for crystallography and in a few weeks had so mastered the subject that he went beyond what was known of this science up to that time. He measured the crystals with a 12-inch Reichenbach theodolite, then calculated and drew their most intricate forms. His method of distinguishing crystals was essentially that announced later by Miller of Cambridge. Soon however Gauss laid aside all papers, observations, calculations and drawings, and with nothing published there was no further talk of crystallography.

With Weber's call in the fall of 1831 work on questions of pure physics quite suddenly took first place. The close and friendly, untroubled living and working together of the two men Gauss once characterized by saying, "The steel strikes sparks." Through it there came in a few years

those memorable, epoch-making 19th century achievements in physics which later found expression chiefly in the field of magnetism.

One day in the winter of 1832 I happened in at the Observatory. Always ready to teach and share his thoughts, Gauss picked up a small box-compass and showed me how the iron rods which closed the windows were themselves turned into magnets through the influence of the earth's magnetism. Like a landslide suddenly set in motion by a small falling stone on a mountain-side and swelling to a size powerful enough to block valleys and force glaciers to a new course, there grew from these smallest beginnings, through the impact of Gauss' creative force, those remarkable investigations which opened an infinite perspective into the future. They had unexpectedly left the road travelled by man for centuries and opened a new road for a reinvigorated Science. The magnetometer in its present form was soon in use, and in the fall of 1833 Gauss gave to the Society his treatise on the Determination of the Absolute Intensities of Terrestrial Magnetism.

The following spring observations were begun on the variations of the Declination, on the basis of the 44-hour periods previously determined by the great natural scientist von Humboldt. Later such observations were begun all over the world after Gauss and Alexander von Humboldt had encouraged the organization of a magnetic association.

Observations set up to use everywhere instruments of the same construction were soon pouring in from north and from south. This led to the discovery that the daily course of the magnet's needle was everywhere simultaneously affected by disturbing forces, a result already suspected but in its universality and precision highly surprising to all physicists.

With the development of the magnetometer and with the observations carried out almost daily on the absolute Declination and its variations, as also on the Intensity, the discovery of the electro-magnetic telegraph is most intimately connected. Different magnetometers were immediately equipped with amplifiers and a double wire connection which at first reached only from the Observatory to the little magnetic house built in 1833 some hundred meters west of it. Hydrogalvanic action of a single pair of plates was to be seen passing from one end to the other of the magnetometer. But in this same year, 1834, induction replaced hydrogalvanism, and thus was the electromagnetic telegraph discovered, now --with various mechanical modifications--in universal use. Single words, then sentences, were telegraphed between the two substations with complete assurance; once in the presence of his Highness the Duke of Cambridge who showed special interest in the new discovery.

Following the entirely successful efforts in Goettingen, Professor Ernst Heinrich Weber of Leipzig reported them at the suggestion of Minister of State Lindenau to the Directorate of the Leipzig-Dresden Railroad and proposed the construction of an electromagnetic telegraph between Dresden and Leipzig. According to an estimate of Wilhelm Weber a double line of copper wire between the two places would need to be of 1.6 mm diameter and 60 cent. weight. Iron wire would need to be 3.8 mm thick and 330 Centner weight.

Ernst Heinrich Weber had grasped the full significance of the great discovery and he closed his report with these words: "If once the earth is covered with a net of railways and telegraph lines, this net will perform a service similar to that of the nervous system in the human body, communicating motion and transmitting perceptions and ideas at lightning speed."

In 1835 therefore Dr. Hülse of the Railway Directorate was sent here to acquaint himself more fully with the set-up of the Goettingen telegraph. After his return to Leipzig in Sept., 1835, Wilhelm Weber wrote him semi-officially, enclosing a plan by Gauss. From the two documents (which it is hoped will later be published) one gets a clear idea of the construction and peculiarities of the electromagnetic telegraph of that day. Gauss says in this paper: "Our way of telegraphing dispenses with all hydrogalvanic current and depends on a particular application of induction. We transmit 8 letters a minute." By a slightly altered arrangement which will be described in more detail in Gauss' documents, it would even be possible to send 20 letters a minute.

The Directorate of the Railway now approved its committee's decision of July 15, 1836, at the second general meeting of the Leipzig-Dresden RR., to move for the building of an electro-magnetic telegraph between the two chief cities of Saxony. Unfortunately railroad shares just then fell considerably in value and the Directorate shrank from every avoidable large expenditure. Thus the decision to unite Leipzig and Dresden by telegraph at that time failed of execution.

It should be noted that in 1837 Herr von Steinheil in Munich, relying on the Gauss-Weber invention, reduced the mechanism of the telegraph to a greatly simplified form (since then entirely altered) by means of which one could use it for speaking as well as for writing.

The conducting wires of the first Goettingen telegraph after ten years of use were largely destroyed on December 16, 1845, by a fierce bolt of lightning. But a short length of wire is still preserved today.

On September 19, 1837, at a session of the Academy of Science during the celebration of the University's 100th anniversary, Gauss put into the hands of Alexander v. Humboldt his treatise on the Bifilarmagnetometer. In this treatise are set forth the methods for using this instrument (now everywhere employed in magnetic fields) to determine variations of intensity with the same accuracy obtained by the magnetometer when observing variations of declination.

In 1840 there next appeared, to the joy of physicists, the long awaited General Theory of Terrestrial Magnetism which placed a new foundation under physics. For two centuries men had been giving close attention to observations of the magnetic declination and inclination, and now in our own times to the observation of intensity, and had been laboring to put these phenomena on charts and globes. Now it was for the physicists to attain a loftier point of view from which to look out over the confused labyrinth of data piling up higher and higher, and to be led toward a general law, away from the ground of apparent chance to the ground of the inevitable.

The assembling of observations on our magnetic charts may be likened, said Gauss, to the visible course of a comet across the sky. Man has only the cornerstone; he can erect no scientific structure so long as these manifestations come under no known scientific law. There was no dearth of attempts to decipher the great riddle, but these only serve to recall the time when astronomers tried to explain the course of the planets through accumulating epicycles, before Kepler's Laws and Newton's Law of Gravitation lifted us to the highest plane of Science, moving like bright sunlight over the dull background of human knowledge.

Thus Newton's creative mind led astronomy to the final principle which controls all science, and Gauss solved the hitherto veiled problem of terrestrial magnetism. This problem might well have had to wait another two hundred years for solution, with its mysterious phenomena and inadequate methods of observation. So in these investigations of our illustrious mathematician the way was indicated which science was to follow in the future, and through them all was scattered a rich sowing of seeds for future generations to harvest. Yet as we read of such intimations we feel deep sorrow that through the loss of this incomparable man our world is the poorer by a whole worldful of thought, and our spiritual course has fallen short of reaching its highest peak.

Besides many small undertakings which are included in Gauss' magnetic findings, we should mention one investigation which he valued as one of his most important, namely the general principle of the operation of forces under the law of inverse squares. With this the findings of the Magnetic Society were in large part closed. From this time on Gauss had still approximately ten working years before him. These, however, slipped by even more quickly than we had anticipated.

Gauss published next an important treatise on Dioptrics, and then two larger ones on Geodesy, which have already been mentioned and which are to be viewed as part of that work so long contemplated but never put through.

In addition to this scientific work he put much time into his academic teaching. His lectures on practical astronomy and on different aspects of mathematics, especially on the method of least squares, seemed to give him more pleasure in his later than in his earlier years.

Though he groaned over the burden he faced at the beginning of each semester, he was soon in the heart of the subject with great zest and energy of mind. Also he felt the stimulation of a larger circle of students than he had formerly gathered about him. At the Senate's request he took over also a reorganization of the University's Widows' Fund, a task he performed with great unselfishness, demonstrating anew his extraordinary versatility and genius with figures. In this his practical talent for organizing large financial operations, his kindness, his sense of justice, his objective approach to all situations were clearly in evidence. His exact studies of nature and the careful uniformity of his methods doubtless helped.

So Gauss cleaned out the Augean stable, bringing a blessing to our widows and orphans (which will last as long as the affairs of men run peacefully) by re-establishing an institution which was on the brink of ruin and which--through mismanagement--would otherwise certainly have gone into eclipse. On this matter a carefully drawn report was laid before the University Council and Senate, embodying the principles to be considered in managing such funds. This was unanimously endorsed. It would be well if this report with its many new ideas could now be made available to more such institutions.

On July 16, 1849, we attended the 50th anniversary of the noble old scholar's Doctorate. A numerous circle of friends, admirers and grateful pupils gathered round him, coming from near and far to express once again their profound admiration and respect. Also there came many tokens of homage, renewed degrees, the keys to the cities of Goettingen and Braunschweig, and various orders of decoration, distinctions accorded even small men.

At a meeting of the Society of Science held in celebration of the day in a flower-bedecked hall, Gauss presented his last treatise: Contribution to the Theory of

Algebraic Equations, in which he treated the same subject with which he had entered on his scholar's career fifty years before, but this time from a general point of view. At the banquet he spoke with emotion of the continuously active, earnest efforts in behalf of science which had ever been the blessing of our University. "Banale phrases had never been accepted in Goettingen," he said. Then he pointed to the helpful attitude of the Council under whose far-sighted leadership the representatives of science were shielded from misfortune and enabled almost undisturbed to devote themselves to research, not seldom reaching notable heights.

On July 26, of the same year, in times otherwise so troubled, we recall still another happy event, the visit of the Minister von Lindenau, last of the old friends from the beginning of the century to see Gauss here.

From then on Gauss seemed to rest on his laurels. He said often to his nearer friends that he did not wish to drive himself and that his working hours were much shorter than in his earlier years. Again he deplored the burden of lectures which took him from weightier investigations. Yet there were few days on which he did not carry on with his research and calculations. For example he worked on the theory of the convergence of lines, on a second revision and balancing of the University Widows' Fund, and still again on mechanical problems connected with the earth's rotation, following Foucault's effort and the theories put out by Lagrange, Plana, Hansen and Clausen.

Practical astronomy and natural science continued to delight and interest him even though he could put into them less time and strength than formerly. Thus he had the Reichenbach meridian-circle provided with new microscopes, observed at such times as he comfortably could several of the newly discovered planets, and ordered from

the Berlin firm of Oertling an optical apparatus, that he might go more deeply into the new theories of light, in which he felt great interest. In fact shortly before his death he designed and made a pendulum apparatus of large dimensions to show the rotation of the earth by striking.

Almost the only physical relaxation Gauss took in his old age was a daily walk from the Observatory to the Library. Here he was regularly to be found between eleven and one o'clock, rapidly going through all the political, literary and scientific journals, culling from each that which was of interest to him. This he would sometimes jot down or he would store it away in his powerful memory.

At home we would find him occupied with lighter reading than formerly. He tired more easily and needed more rest. No small part of his time still went into his extensive correspondence with friends and scientific associates all over the world, though many of the old bonds had been broken by death. Already laid aside for several years were the pens of Olbers and Bessel. With Schumacher in Altona he exchanged weekly letters as long as the latter lived. Also with Alexander v. Humboldt he was in close, though not such regular touch. Several months before this great scientist would have reached the age of Newton he marked the day on his calendar, and when the day came round expressed to him his heartiest good wishes.

In February of 1851 death took from us our friend Professor Goldschmidt. The previous night he had been observing in the Observatory and had shown some friends the Pleiades in a telescope. Next morning he was found dead in bed. The sudden passing of a man so highly valued by us all for his kindly character and his sound scholarship and so closely associated with Gauss, and for whom Gauss felt such deep admiration, was for all of us a deep blow.

In the two following winters Gauss complained repeatedly of his health. He suffered from sleeplessness and shortness of breath, also from congestion which he thought was the main trouble. He had adopted the simple remedy which seemed to help him of getting up every night about three o'clock for a drink of Selters water and warm milk. In all his long life he had till now allowed himself to be given only two prescriptions and those by Olbers forty years earlier. He had scant confidence in medical science and now in his failing health was for a long time opposed to calling in a physician.

At length the repeated pleas of those close to him persuaded him to call in our common friend and colleague Dr. Baum. This was on the 21st of last January. An examination which continued over several days showed the trouble to be enlargement of the heart, an illness which would probably be fatal and of short duration. The trouble seemed to be an old one, though grown conspicuously worse in old age. Olbers many years before had recognized or suspected it and advised caution. The use now of specific remedies combined with the coming of warmer weather worked such improvement that in the course of the spring and summer Gauss was again seen almost daily at the Library between the hours of eleven and one. He could also take short walks here and there in the neighborhood.

He took great interest in the building and management of railroads, though for over twenty years he had not spent a night away from Goettingen and had therefore seen nothing of the new developments. But this interest led him on June 16th last to visit the railroad under construction between here and Cassel. Unfortunately a passing locomotive frightened the horses of the carriage in which Gauss was riding with his daughter, the carriage was overturned and the driver seriously injured. The aged

man and his daughter miraculously escaped all injury and both returned unscathed to the Observatory.

On May 21st the newspapers announced the death of Bernard von Lindenau. The news appeared to touch Gauss so deeply that we avoided speaking of it. But he kept coming back to it and the memories of their old friendship, dwelling on Lindenau's disinterested, noble character, to which he ascribed the success of his diplomatic career. No thought of his own approaching end seemed to touch him, whether because he was shutting it away or more likely because he did not believe his end was so near.

After some weeks, on July 31, the official opening of the railroad between Goettingen and Hannover took place. It was a fine summer day and Gauss was well enough to go downtown and view the celebration from various places. It was however the last day we saw him in tolerable health.

With the coming of fall the disease took fresh hold on him and as the weeks passed we did not hide from ourselves our friend's increasingly serious condition. A swelling of the feet which in lesser degree had for a long time been observed but which he seemed to view as of little consequence, now forced him to remain housed and to give up his walks to the Library; even the few steps in his own house became difficult for him as the shortness of breath increased.

On December 7th very disquieting symptoms developed and Baum did not expect him to survive the night. But once again the strong spirit kept the weakening body together. After a quiet night Gauss was definitely better the next day and wanted to return to his accustomed routine as soon as possible. Though he could not work continuously toward the end he was still always mentally occupied. He read

much and often for very long periods. Also he wrote each day although with much greater labor. He still noted down various memoranda and wrote letters. The last letter of all, a keepsake to be honored by him who possesses it, went to Sir David Brewster on the subject of the discovery of the electric telegraph.

The last evening of the departing year I visited the great man as usual. I saw him but briefly, finding him in comparatively good spirits, but left him knowing that we two would never celebrate another New Year together. In the early part of January Gauss was very miserable and saw hardly any visitors, yet hoped confidently to be better presently and wrote on January 5th to Architect Prægel concerning repairs to his dwelling planned for early spring. Only now did his beautiful handwriting become faltering, something which had not been the case before.

With the ups and downs of his illness I did not see Gauss again till January 14th. At that time the Sculptor Hesemann of Hannover had just arrived on commission of his Majesty the King to make a medalion of the great mathematician. He planned to begin work the following morning. I found Gauss weaker but cheerful. He related some incident out of his earlier life; his blue eyes sparkled, the last time I saw them so.

On February 21st I saw him for only a few minutes soon after mid-day. He was still fully conscious, as he was up to his last hour. But he was strikingly altered, for Death hovered close. I pressed his hand once more and left the room. I did not again see him alive.

February 22nd soon after mid-day he passed through his last hard struggle. Then toward evening it seemed to be better with him, and though his eyes were already

closed on this world, consciousness had not left him; he heard everything that went on about him, inquired about those present in the room and asked for a drink. Then came the need for rest, the balm of eternal sleep. We sat in the next room and hoped for a better night. His heart continued beating, but the breath grew shorter, ceasing altogether at times, then beginning again. Then the intervals became longer, and on February 23rd at five minutes after one in the morning he drew his last breath. Also at a few minutes after one his watch stopped, the watch which had gone with him through the best part of his life and which is something an astronomer does not easily forget to wind.

It was over. The noble soul had breathed its last, called home for completion of the work it had begun. It had entered that realm washed by the peaceful waves of Eternity, in which live only great thoughts, great feelings, and in which there is no pain, no sound of earthly mourning, where are left behind the sad scenes of decay.

Next morning the great man still sat in the arm-chair in which he had gone to sleep. His noble head with its silver hair was bent forward almost to his breast, his tired eyes were closed. The last sunset glow of his earthly world of thought seemed to envelop his high, nobly thoughtful brow, and the mildness of the spring rested like a benediction on his kindly features. Earthly pain was overcome and there remained for us only the tears, the sorrow, and the hope of another meeting. It was for me a touching, deeply moving, and unforgettable picture to see now before the dead man the faithful daughter and nurse of his old age, her task performed with such high devotion and filial love. She knelt at his feet, smoothed his silvery hair, kissed and caressed his face as if she would call him back to life. It was so still every breath was audible, only not his.

The night of February 25th was the last Gauss spent in his room. With a simple black casket made ready, only those closest to him performed the last duties; no undedicated hand touched him. We made ready his quiet couch, placed him on it, and wreathed his noble head and peaceful face with fresh laurel and spring flowers.

Next morning by nine o'clock the casket stood open in the rotunda of the Observatory, crowned with cypress and surrounded by lighted candles. It seemed as if for the ceremonies of these grave hours the countenance of the dead man had taken on another expression. The grandeur of his features had supplanted the earlier mildness; the high forehead surrounded by laurel, the eyebrows with their characteristic and slightly irregular modelling, the aquiline nose and still mouth combined to give an impression of consecrated solemnity and impressive dignity. It seemed as if he would say: "My great life course is run. I can look back on my life serenely and look forward with hope."

There had meantime gathered the Fellows of the University, the Mayor of the city and numerous friends and admirers of the deceased. The casket was placed on the terrace by students of mathematics and of natural science. Then followed the chorale, "Eine feste Burg ist unser Gott." Words of farewell were spoken by two close friends, after which a long procession accompanied the dead man to his last resting-place. There the pastor pronounced the blessing and the casket was lowered into the earth, covered with palms and laurel. Nature's frosty shroud soon enveloped the quiet grave, which we hope will be marked with a granite shaft for the benefit of coming centuries.

The great man's features and still more his inner nature and powerful work are imprinted deep in our

memories. That his likeness should be preserved also for coming generations is therefore a matter that concerns us. First, there is a bust modelled from life when he was in his 34th year. In this the face and forehead are excellently reproduced, but the back of the head is poor. Then we have also an excellent, very life-like oil portrait done by Janssen of Copenhagen. The original is in the Royal Russian Observatory of Pulkowa near St. Petersburg. Three copies of this are in Goettingen. From one of them was made the well-known steel engraving with the motto from King Lear. Also we have the successful medallion by Hesemann, made this past January, and a death-mask which we hope will serve as a guide for an excellent bust. And last of all Herr Petri here in Goettingen, skilled in making daguerreotypes, has made several pictures, two showing only the head, two the whole figure in death. In these we see the great mathematician as he rested in quiet peace in his room that last night before his burial, robed in his scholar's gown. Unfortunately there exists no photograph from life.

Adequately to describe the character and the manner of mind of this man is a task which I well know is beyond my powers, - a man towering high over our Age, to whom aspiring mankind and above all the better part of the German nation can raise justly proud eyes, a man who in his own inspired life reaped as rich a harvest as he sowed for future generations. Yet if in concluding these pages I attempt in some measure to do this, I hope for kind indulgence from those who are convinced of my aim and deepest desire to fulfil a sacred duty.

The son of poor but upright parents, Gauss was from his youth accustomed neither to the luxury nor the refinements of our day. The very scanty means which provided for his early years were enough for his small needs. From childhood on he knew how to spend carefully the little that he had, so that there was always a little left for the unexpected, enough to prevent his needing to turn to others for material aid. A high sense of personal pride as well as his inborn independence of spirit doubtless held him to this, - an attitude from which he never swerved.

So it was that in mature years he felt it impossible to accept assistance from private sources, even from his closest friend Olbers, as likewise from Laplace, when they wished to supply the sum needed for the French war-levy at a time when Gauss was in real need. He accepted the support of the Duke of Braunschweig because this had to do with his work and not with him as a person.

The restricted circumstances under which Gauss grew up left on his spirit no trace of depression. He was cheerful, gay, forward-looking. The goods of this world which Fate denied him seemed to him superfluous, almost disturbing. In the years of his early development he remained rather apart from the world, since after Bartel's departure no one in Braunschweig was able to follow his studies.

At various times Gauss remarked to me that only for himself, that is from the deep urge of his own soul, was he pursuing his scientific investigations, and that it was to him of secondary interest that his work should later appear in print in order to reach a wider circle. Another time he said that in his youth his thoughts streamed forth in such an unbroken flood that he could hardly control them.

and was able to record them only in part. This explains the fact that often his greatest discoveries lay for decades in his writing-desk without being made public until later the same things were discovered by other mathematicians. In part also the manner of presentation and the final editing of his works, of which we will speak below, had something to do with their delayed publication.

When a task which had perhaps occupied him a long time was completed he was accustomed frequently to enter only the end-result on a slip of paper or in a small notebook, in the neatest of figures. It was then put aside and years might pass before it was again called forth. How many thoughts may have risen up in this powerful brain with its incredible productivity, to be again submerged! lost to science! -- at least for the time being.

Gauss said of himself that he was wholly a mathematician. To be anything else at the expense of mathematics was an idea he repudiated. Yet the natural sciences also drew him. On the occasion when he copied the motto from King Lear,* lines he treasured and loved, I heard him say it was a fitting motto for a natural scientist:-

Thou, nature, art my goddess, to th~~x~~y laws my
services are bound.

To use Gauss' own words, mathematics was for him "the Queen of sciences, and arithmetic the Queen of mathematics." It may often stoop to do a service for

* Note: From Shakespear's King Lear, Act I, Scene II, where however it has a different meaning. Gauss wrote Laws in place of Law, a small change essential for its application to the natural sciences.

astronomy and other natural sciences, but under all circumstances it must take first place. Gauss saw mathematics as the prime building-stuff for the human spirit, yet gave full recognition to the study of classical literature, and said occasionally he had not ignored the latter, though he had chosen to follow the former.

In all mathematical research he placed at the top rigorous analysis. This was strongly emphasized in the congratulatory message of the Berlin Academy on the day of the anniversary celebration. This pointed out that Gauss was the mathematician of modern times who had brought the long-lost austerity of the Greek geometers again into acceptance and had introduced it into the higher branches of mathematics.

Through the study of Euclid and Archimedes he could only be confirmed in this attitude which so accorded with the bent of his own genius. Moreover to young and promising mathematicians he always urgently recommended the study of the ancients.

Although Gauss was better acquainted than was perhaps anyone else living with analytical calculus, he was strongly opposed to every mechanical handling of it and tried to restrict his own use of it so far as possible. He often said that he never started a calculation until the problem was fully solved in his own mind. Thus for him calculus was only a tool for carrying through a task.

In discussing these things he once remarked that many of the most distinguished mathematicians, Euler very often, and even Lagrange occasionally, trusted so much to calculus that they were unable to account for their investigations at every step of the way. Of himself he could say that with every step he took

he always had definitely and undeviatingly before his eyes the end and aim of his task. The same was true of Newton.

For greater certainty and control of calculations Gauss tried so far as was practical to support his computations with geometrical principles. He further demonstrated his general theories by applying them to practical examples. In early youth geometry inspired little interest in him. Only later did this develop in high degree.

It was especially noteworthy and illuminating to see the principles on which mathematics is based laid bare by Gauss, and to see them sharply distinguished from metaphysics. Although Gauss never published anything on these questions, we may well suspect that something may yet come to light in his scientific estate. In earlier years when his course in life was not yet determined and he had to think of the possibility of somewhere being a teacher of mathematics, he worked with this in mind on a paper which is said to have come to hand in these last years and in which he treated the rudiments of mathematics philosophically. It is doubtful if this is still in existence.

Geometry was for Gauss a consistent structure, with the theorem of Parallels standing as an axiom at its peak. He was convinced nevertheless that this proposition could not be proved, though shown by experience with the angles of the triangle Brocken, Hohenhagen, Inselsberg to be approximately correct. If however people were not willing to accept the axiom named above, there would then follow another quite independent geometry which he had once briefly pursued and had called Anti-Euclidean Geometry.

According to his frequently expressed convictions Gauss regarded the three dimensions of space as a specific

characteristic of human beings. People who could not understand this he humorously called Boeotians. "We can think of creatures who are conscious of themselves in only two dimensions," he said. "Higher above us in like manner would stand those who look down on us. Certain problems pertaining to this", he continued jestingly, he had "put aside to deal with later through geometry, in a higher state of existence."

Gauss' aim was always to give his investigations the form of perfect works of art. He would not rest sooner and never gave a piece of work to the public until he had given it the perfection of form he desired for it. A good building should not show its scaffolding when completed, he used to say. In his demonstrations he used almost entirely the synthetic method, which he had come to prize through his studies of Archimedes and Newton. It is distinguished from the analytic method by its brevity and comprehensiveness. But the road leading to the discovery remains veiled, and indeed it often seems that Gauss frequently and intentionally turned aside from the road that led to mere instruction.

It is not to be denied, he often said, that this ingenious method of demonstration, which made the reading of his treatises much more difficult for those less versed in mathematics, also cost him much time. But having chosen this path in his youth he was unwilling to desert it later. It is explained in the motto on his seal: "Pauca sed matura." (Few, but ripe.)

Some eminent mathematicians of recent times have expressed the opinion in connection with Gauss' discoveries that it would have been better for the advancement of science if he had attached less importance to this perfection of form and had instead given out more of his inexhaustible ideas, which are lost to us insofar as they are not noted down.

Gauss' writings delved into the most varied branches of mathematics, astronomy and physics. Through their wealth of material as well as through their unimpeachable correctness they won the universal admiration of all the initiated. It is indeed remarkable that in so many deep-plunging investigations no man has been able to find any error other than a misprint.

Mathematical research had value for Gauss only when it was the culmination of long mental effort. He never rested until he had solved the problem before him. Were other people but willing, he said, to ponder mathematical truths as deeply and continuously as he did, they too could have arrived at his discoveries. Often for days he had pondered in vain over one or another piece of investigation without reaching the answer, when all at once--perhaps on a sleepless night--this would come clear to him. In talks with others he would often become suddenly silent, especially in his younger years. Staring into space he would seem to be intently following some new thought. Conversation would cease, to be resumed some days later after ripe consideration.

Gauss' extensive knowledge was amazingly at his command. His unexcelled memory for figures especially excited our wonder. If a question was put to him which he did not wish to answer immediately, or could not, one might be sure that there would shortly follow a discussion of the subject, either orally or in writing, which would leave nothing to be desired. During his active years he enjoyed sharing such matters with his pupils or young friends.

Gauss had a remarkable combination of rare endowments, a combination perhaps never in such high degree equalled. To his striking ability to work out abstract questions in

every field and from varied standpoints was added the amazing gift for numerical calculation, the peculiar gift for a quick grasp of the most involved relations of numbers, and finally special delight in the exact observation of nature.

Archimedes, with his inborn logic in addition to his mechanical gifts, seems to have been a nature closely related to Gauss. But under the conditions of his time his gift for combinations of numbers could not be developed. Gauss often said to us that Archimedes was the man of antiquity he most revered. He pictured him as completely noble in appearance, old and dignified. But he could not forgive him that in his reckonings in the sand he had not hit upon the decimal system. "How could he have missed it!" he exclaimed. "And on what heights science would find itself today if only Archimedes had made that discovery!"

Still closer was the spiritual kinship of Newton and Gauss. Indeed Gauss cherished for the great English scientist an unbounded admiration and in his writings usually referred to him as "summus Newton", a term he applied to no other mortal. Indeed Newton's exalted genius was revered by Gauss as by few others in like degree. Gauss expressed indignation that the great discovery of the law of gravitation was said to be attributed to petty chance.

"The story of the apple is too simple," he said. "Whether the apple fell or remained where it was, how can one believe that through it such a discovery was hastened or delayed. The circumstances were probably like this. There came to Newton sometime, somewhere, a stupid bore of a man who asked Newton how he happened on his great discovery. Newton, seeing clearly what kind of an ignoramus he had before him, and wishing to be rid of him, probably answered it was an apple which fell and hit him on the nose. Whereat the man went contentedly away, fully enlightened."

The two outstanding personalities of the 17th century, Newton and Leibnitz, have often been compared. Gauss likewise did this. He recognized indeed the high genius of Leibnitz whenever he spoke of him and did not underrate his services in the discovery of differential calculus, but he censured him for having occupied himself with everything under the sun and at the cost of mathematics. Therefore the achievements of Leibnitz could not be remotely compared with those of Newton.

The mind for experiment as well as for numerical calculation was peculiar to both of these great mathematicians, though in calculation Gauss far excelled all others, living or dead. We were constantly overwhelmed by his complete mastery of the world of numbers as we saw it on every side yield to his genius. For example he could name off-hand or at least after very brief reflection, the characteristics of every one of the first couple of thousand numbers, and with these still keep in mind the later ones. In mental reckoning he was unexcelled, though he placed no special value on this gift, "since up to a certain point it was a necessity." We saw daily astonishing instances of this gift. Likewise the first digits of all logarithms were always stored in his mind, to be used for rough mental calculation. Often a many-sided closely-packed calculation continuing over days and weeks, with number crowding on number, calculations which to others less expert presented insuperable difficulties, seemed to him neither baffling nor exhausting, but all in the day's work. It is possible that some skilled calculators can resolve long and involved calculations just as quickly by using accepted shortcuts. The remarkable thing with Gauss was that in all tasks of this kind on which he embarked for the first time he was always finding new paths, new methods, new devices through which he could always enliven a tedious task with fresh interest.

In larger tasks where it was a matter of obtaining an important result he rarely made an error, for he knew how to weave into these computations so many expert controls that an error was almost impossible. In all extended computations he observed a standard pattern. Every figure was most neatly written, each stood in its right place, row under row with unvarying precision. Gauss' aim was always to carry out the task as exactly as the means at hand permitted. Thus the last decimal in the 7 or 10-cipher logarithms must be carried out as far as possible. And in this connection he pursued extensive investigations of his own as to how far in the different tables the last decimal was reliable. Reckoning with incorrect tables gave him a special pleasure, since then, on the side, he had the agreeable opportunity of correcting what errors of printing or reckoning might appear. But his greatest pleasure was to simplify as far as possible interminable analytical or numerical calculations, finally to condense them into small compass, and sometimes to present on one side of an octavo sheet the results of a task which had taken weeks, making all clear to the initiated. Also where he had to make excerpts from the works of others, the contents of a volume or the digest of a whole pile of reports was so concisely put together as to require little space.

The peculiar combination of Gauss' gifts, the acuteness of his mathematical powers and the ease with which he mastered computations were in essence the explanation of his success with astronomy. As long as he lived he found both pleasure and exhilaration in astronomy.

In the letter we have already quoted Olbers wrote that Gauss "loved" astronomy, and most particularly practical astronomy, wherefore he desired to divide his time between this and his profoundly deep mathematical

investigations. Some great mathematicians have regretted that Gauss did not confine himself entirely to the field of mathematics, and it is true that this science suffered for the sake of astronomy and geodesy. As we have already noted Gauss himself ranked mathematics as Queen of the sciences. But he obviously felt the need at times to rest from exhausting investigations and it was in the study of nature--in astronomy and physics--that he found recreation. His profoundest joy was to listen to Nature in her deeper moods. The exact observations he always made at such times then served as starting-points for new investigations, new theories. To all observations in either astronomy or physics he sought to give all the precision which observer and instruments could supply, just as he executed numerical calculations with all the exactness the means at hand permitted.

The construction of instruments he grasped intuitively. Once their purpose was defined he was able to produce a geometrical drawing of them which showed their function clearly and graphically. All errors to which observations by a given instrument were subject were then investigated and the manner of their correction indicated. This exactness in understanding and criticizing the performance of an instrument was increased by his natural taste for it, especially in his younger years, by his restless ardor, his great skill and marked success. In the latter half of his strenuous life he was glad to turn over to his pupils those daily recurring observations which he had himself previously conducted. His eyes, nearsighted from youth on, were sharp and his ears acute for time-intervals. Every phase of physical astronomy was of keen interest to him even when there were no exact aspects to observe and even though he might consider it quite beyond the bounds of pure science. However, when the application of mathematics seemed to promise any reward he put into the task just that much more zeal.

We recall the time when the moon-chart of Bear and Mädler appeared and Gauss stood at the telescope almost every clear evening to observe the surface of our nearest neighbor from different angles and under differing conditions. Again we were surprised by the short time it took him to orient himself in this new field.

Likewise other phenomena of the heavens kept him pondering and observing. Variable stars, double-stars, nebulae, the nature of the surfaces of sun and planets, the appearance of comets, shooting-stars, zodiacal light and many other phenomena all claimed his attention. From time to time he let fall a few comments on these matters, but attached no weight to them. Prevailing views on one or another such matter he now and then rejected without communicating more at length his own thinking. Among other things he held order and conscious life on the sun and planets to be very probable and occasionally called attention to the action of gravity on the surface of heavenly bodies as bearing preeminently on this question. Considering the universal nature of matter, there could exist on the sun with its 28-fold greater gravity only very tiny creatures somewhat like cock-chafers, whereas our bodies would be crushed and our limbs broken to bits; then he added whimsically: "Yes, on the sun there is room for us all; only each one of us to be sure would need his own valet."

When in the mood Gauss took pleasure in looking to the future of Man's development and especially to that of his beloved science. He seemed to expect most from the further development of mathematics and the theory of numbers. He placed extraordinary weight on the development of topology, in which wide and wholly unexplored fields lie open, completely beyond the range of our present-day calculations.

It accorded with his character, with his investigations of pure mathematics and his studies of the natural sciences that he carried over to all other situations in life his methods of close observation. Wherever possible he sought to base his experience on numbers. Beyond all else he was concerned to turn a new page for the application of mathematics. He therefore kept the most varied register of numbers, entered most neatly and precisely in small books. For example he had reckoned in days the life-spans of important men, including his deceased friends. Also he registered the monthly receipts of the Hannover Railroad; again the steps from the Observatory to those places he was accustomed to visit; the dates and the number of thunder-storms in different years, and so on.

In life's manifold situations he saw a broad and open field for the application of mathematical theories. The answering of questions on national economics, finance and statistics gave him rich material for such investigations. To mortality tables and the exploring of laws under which life spins itself away, he attached special importance, in part for the purely scientific side, in part to study their application to life-insurance annuities, widows' funds, etc. Gauss' careful investigation of our University Widows' Fund I have already described in some detail. It is only another example of his thoroughness and exactness applied to specific situations.

In mortality tables Gauss was especially interested in the two extremes of man's life, where a far greater uniformity of law is to be seen than in the intervening years affected by so many strange and incalculable influences. He told us once that he had "started studies of his children's developmental stages in their first year and a half, and these showed such an amazing uniformity that they were scarcely inferior to astronomical observations." In like manner he believed that in advanced

age the average life-expectancy followed strict law. For answering these questions there were unfortunately too few observations, a lack that could be corrected by granting rewards to those reaching a proven age of 90 or 100. If he were rich he would set aside money for this, he said.

State finance, revenue and outlay, bank and railroad management, the ratio between coin and paper money, amortizations etc. were all among his special hobbies. There was seldom a day when he did not follow the market on government bonds, shares and money-exchange in the many different newspapers he rapidly perused for amazingly quick comparison. All paper money he considered a menace to the State, since in times of need governments could easily be led into overestimating their strength. He felt the nation could be congratulated on having thus far avoided it. He was a resolute enemy of small financial operations which burdened the people without appreciable results. He labelled these penny-wise and ascribed to their authors little sense or judgment.

Without question Gauss would have made an outstanding minister of Finance, operating with consistent skill, prudence and integrity. We must indeed thank Providence that these gifts did not become known to a wider circle, for innumerable demands would without doubt have kept him from his purely scientific occupations. Thus, preeminently occupied with mathematics though he was, wishing to be known only as a mathematician, he was far from having mind and inclination for this science alone. Indeed all that moves the mind and heart of man stirred his sympathy and kept him pondering.

After mathematics is to be noted first his talent for widely different languages. With the classic languages he was familiar from his youth on, and most of the modern

languages of Europe he could read. The more important ones he spoke and wrote with complete correctness. His mother tongue he used with a freedom, a force, dignity and precision suiting the subject. In his advanced age (his 62nd year) he decided that in addition to his regular studies in mathematics he must find a new means of keeping his mind alert and active and receptive to new impressions. He gave passing consideration to botany, but since this would involve considerable physical strain he turned tentatively to Sanskrit. This too did not satisfy him. So he took up Russian with such zeal that in two years he had mastered it to the point of reading easily all books of prose or poetry and at times carrying on his correspondence with St. Petersburg in Russian. When visited one day by a Russian state councillor he conversed with the latter in Russian and with a wholly Russian accent, reported the official.

Gauss valued languages in general according to their logical exactness and richness of the concepts which they were able to convey. Often he lamented their inadequacies, particularly when it was a matter of precise description of strictly scientific phenomena. At such times--though cautiously and only when strictly necessary--he tried to introduce for new concepts new expressions, which indeed soon received general acceptance.

Almost the only recreation which he allowed himself as a change from his mathematical studies was extensive reading in the most varied fields of human knowledge. The fine literature of Germany and England chiefly attracted him. In later years he spoke also with great esteem of the Russian.

Among our German poets he placed Jean Paul definitely in the front rank because of his richness of thought, his deep kindliness and his inexhaustible humor. The Campanerthal he highly esteemed, though the grounds which Jean

Paul gave for the immortality of the soul he considered to be of but a negative nature. He often deplored the blind alley to which the poet had brought himself by his belief in animal magnetism, and through which the fine effect of what went before was sadly weakened. Dr. Katzenberger's Badereise he pronounced a successful book and he always laughed over the struggle of the doctor and the apothecary for the 8-legged hare and over the art of making the ducats look like gold with ear-wax. Gauss and Jean Paul had a mutual respect for each other, but never met.

The great mathematician could not enter so readily into Goethe's writing and thinking. Though he undoubtedly knew the poet's works well he was only incompletely satisfied with them. For him they were poor in thought, Goethe's lyrical poems he appreciated and valued for their finished form, yet he did not rate them highly. Still less did Schiller mean to him, - his own philosophy completely at odds with Schiller's. Schiller's Resignation he called blasphemous and morally decadent. In the margin of his copy he had carefully printed the word "Mephistopheles!" with an exclamation point. Among the dramas he valued Wallenstein's Lager. The Piccolomini and Wallenstein's Death left him completely cold; the hero excited no interest in him, a view others indeed have shared. Schiller's little poem Archimedes he inscribed "admired", though criticizing the unfortunate handling of the couplets.

Gauss did not enjoy tragedy. Misanthropic, life-weary, pessimistic tendencies were all uncongenial to him, tendencies resounding too often in Byron and through him entering German literature. The young Englishman's type of mind seemed to him unwholesome and decadent, quite alien to his own.

I seldom heard him speak of Shakespeare, but he was a warm admirer of Sir Walter Scott and knew his works thoroughly. Yet the tragedy of Kenilworth made so painful an impression on him he would rather not have read it. Scott's Life of Napoleon, a work on which opinion is divided, he read with close attention, commenting that he was satisfied and agreed with the author. One day he noticed in Scott a passage which greatly amused him and set him to comparing all editions which were at hand. The words were: "The moon rises broad in the northwest," a shocking sentence to an astronomer. He laughed heartily and marked the spot.

The English historians he read also with attention. Some years before his death he read with interest Gibbon's Decline and Fall of the Roman Empire and Macaulay's History of England. He took a deep interest in the political development of nations and particularly in that of our Fatherland. This interest showed itself in his daily visits to our Library to peruse the newspapers of different countries, from the English Times to the German Wochenblatt.

His political views often differed considerably from ours, but one could never deny their character and consistency. By nature an aristocrat Gauss was thoroughly a conservative and would have preferred above every other an absolute rule, but one directed by a higher intelligence. The rule of the rabble with its deeds of violence, and especially the Bloody Blouses of Paris in 1848, filled him with unspeakable horror. He had but a low opinion of the intelligence and morals of the masses and often gave expression to it in connection with political, religious and scientific matters. "Mundus vult decipi" (the world wants to be deceived) he would say. He followed agitators and insurgents with the mistrustful eye of a falcon.

He had slight regard for our constitutional form of government and was constantly at pains to point out the faulty reasoning or the ignorance of our parliamentary leaders, and often all too successfully. In his old age he wanted quiet and peace for his country, and the thought of seeing civil war break out in Germany was like the thought of laying himself down forthwith in his grave.

Our readers would form a false picture of Gauss if they thought him capable of clinging obstinately to the old and traditional merely because it was traditional. When it concerned progress that could be demonstrated, whether in material or spiritual things, he was as eagerly alert and ready for change as were any of his contemporaries. Yet in his home surroundings he liked no innovations. For more than thirty years everything remained practically unchanged. He clung to the simplicity he had known in his youth; many of the conveniences of modern life were unknown to him; indeed he seemed to scorn them as hindrances to his aims.

The independence he wanted in his own household he wanted also for the State. Foreign domination of his Fatherland was abhorrent to him. Just recently he called attention to the words of a new writer which he said he completely endorsed: even if the political conditions following the Peace of Paris had become still more deplorable than they already were, our first need was to resist foreign domination. Our political trend, our lack of vision distressed him, and one day, more than a year before the great catastrophe, standing with me on the terrace of the Observatory, he gave vigorous expression to this feeling: - A firmly unified Germany was what was essential. To this end he would willingly have entrusted our fate to the strong hand of one ruler; he had no mind for a weak reed bending before every breath of wind, nor for a ship driven hither and thither without a helmsman.

Gauss was a man of iron character who respected only strong characters. All unsteady, irresolute tendencies, all half-men (of whom there were many) were odious to him. His own unswerving life-purpose was embodied in his large scientific aims and constant striving to lead the exact sciences of the 19th century to new heights, new consummations. This aim of paramount importance he pursued with indescribable energy, inspired with a strength of will and a capacity for work seldom equalled. In a comparatively short time he could accomplish Herculean tasks. The combination of these special gifts with his great genius and almost perfect health--up to his last years--brought forth those great discoveries which we revere today and which posterity will ever hold in grateful honor.

Gauss was a born academician with an innate comprehension of science. To exchange thoughts with spiritually congenial souls was his greatest delight, a joy denied him in his youth when he is said to have had almost no associates with whom he could discuss his deep arithmetical investigations. Applied science was for him of secondary importance, though he did not underrate it. Likewise all routine teaching at the University was uncongenial to him. How often have we heard him lament the fact that this prevented him from executing many an important task he would gladly have undertaken! Once he had set himself to lecture to a small group, however, he revealed himself in full stature, - his presentation clear, original, in high degree stimulating. In the course of time he thus prepared a widening circle of younger men, partly orally, partly by his writings, who have striven to carry on in the direction he pointed out.

For us Gauss was the lofty image of a completely true nature, both intellectually and emotionally. All pretense was repugnant to him. All charlatanism (especially scientific) he treated with sovereign contempt or

sharp irony. "That man is most contemptible who sees his mistakes and still clings to them" he once said to me. This thirst for truth, joined with a holy urge toward righteousness, were his preeminent characteristics. Both passions were rooted in the depths of his being, coinciding closely with his philosophic and religious views and unquestionably further developed by his lofty studies of nature. The principle of the least force was in fact the embodiment in mathematics of the ethical principle which he recognized as binding for the Universe.

All philosophical investigations had a great fascination for him, though he often took exception to the course followed in reaching them. He once said: "There are questions calling for answers on which I would place an infinitely higher value than on mathematical questions. For example: ethics, our relation to God, our destiny, our future. But their solution lies beyond our reach, and quite outside the realm of science."

Under science he understood that logical, strictly unique structure of which the foundations rest on certain truths universally recognized by the human mind. This once admitted provides an immeasurably wide field for the most complicated investigations strung together on an iron chain of thought. He therefore, as already noted, gave to mathematics the topmost place, and when it came to questions which could not be scientifically resolved he used to say "God arithmetizes," thus acknowledging those fields into which our minds are not permitted to penetrate.

Nevertheless Gauss himself never ceased turning over such questions in his own mind and was constantly at pains to bring his scientific experience into harmony with his world philosophy. Yet he held all philosophic concepts

to be subjective and alien to science insofar as they lacked scientific proof. We attribute to this the fact that he never wrote on philosophic questions and only seldom spoke of them.

It is therefore easy to understand that Gauss did not favor the application of mathematics to psychology, as attempted by Herbart and some other philosophers. On this subject he expressed himself only this last year as follows: "In earlier years I thought I would have to teach mathematics and with this in view I prepared a paper which I ran across some years back but which perhaps no longer exists. In this I had set down my thoughts on the foundations of mathematics and in one place I said this: "Extensive magnitudes I understand as those which by reason of homogeneous parts can be put together; these form the material of mathematics. Intensive magnitudes can be included only so far as they can be made extensive and a scale provided by which they can be measured and compared. It would be to the credit of a metaphysician to state the starting-points for a tolerably exact investigation. And crude though the first results proved to be, one could still hope to get further in time."

A vast and lofty cosmic outlook penetrated Gauss' inmost being. And inseparably bound up with it was that exalted religious conviction which illumined his great spirit with a holy sense of calm, confidence and peace.

It was natural for him to scatter before him like leaves in the wind isolated thoughts on forever unsolved questions, thoughts that moved him deeply. Yet before there could be further development of them, they were blown away as quickly as they had come. A humorous turn or a sudden shift of the conversation to ordinary affairs left them behind in a veil of mystery. One day he said to me: "It is all the same to me if Saturn has five or

seven moons. There is something higher in the world." Then he was silent and we sat for several minutes facing each other without speaking. The light in his eyes revealed the flood of thought surging over him.

Our readers will doubtless wish--and expect--to have a closer description of the religious life and religious views of this immortal scientist. Through the long and friendly association which by great good fortune was my lot there was no lack of opportunity to get many deep glimpses into this side of his life, a side usually concealed by his scientific investigations. But however I might wish to attempt a true presentation according to my best knowledge and convictions of the astronomer's religious views, I would inevitably be charged with having confused my own with his. I could too easily be misunderstood. Moreover I doubt if it would be in accord with the spirit of the departed so soon after he has left the scene of his activities immediately to spread out for thousands what all his life he kept in the stillness of his own heart or shared in intimate talk with only a very close circle.

Nevertheless I venture to express the hope that for the distant future when we here are gone Gauss' lofty religious outlook will not be lost, for we know that notes in his own hand have been found. These may well prove to be the best means of refuting incorrect assumptions on this subject.

Without going further into the particulars of Gauss' religious attitudes I would like to touch on those aspects which are apart from all questions of faith and which more clearly depict the character of the man. First I cite the religious tolerance which he extended to every faith sprung from man's heart and which should not be misconstrued as religious indifference. On the contrary Gauss took the deepest interest in the religious evolution of ma-

and particularly in that of our century. As for the manifold varieties of religious faith with which his own views frequently differed, he ever stressed the fact that no man was justified in disturbing in any way the faith of others who found in it comfort in earthly afflictions and a certain refuge in time of trouble. But this same tolerance which he readily accorded to every religious creed he also claimed in full measure for himself. I suspect that anyone who made so bold as to dispute his religious views would have met with very lively opposition.

The foundation for Gauss' religious convictions was his insatiable thirst for Truth and his sense of righteousness extending to matters both material and spiritual. These two complementary tendencies clearly revealed his true character and were revealed conspicuously many times over in even the smallest situations. Each and everything he did must be done with utmost exactness, utmost conscientiousness. In dealing with observations for example he strove to wrest from them all they had to give. When carrying out a scientific calculation, however large or small, he gave it all the exactness the means at hand permitted. In money transactions with anyone he was accurate to the splitting of a penny. He was the basic type of an upright man: strictly to fulfil his obligations was for him a fundamental principle. But from others he also demanded the same uprightness he practised himself. Anyone who might have ventured to deceive him in even small matters or to deviate from strict honesty in dealings with him would assuredly have forfeited once and for all his respect and confidence. He was on guard however not to let himself be deceived, presumably taught by experience; his penetrating knowledge of men enabled him quickly to separate the wheat from the chaff.

To repeat, the search for Truth and the feeling for righteousness were the basis of his religious views. Thus he conceived of spiritual life throughout the Universe as a state of Righteousness penetrated by eternal Truth. From this he drew the trust, the confidence that our life-course is not ended by death.

"There is for the soul a satisfaction of a higher kind," he said once, "for which the material is wholly unnecessary. Whether I apply mathematics to a couple of lumps of dirt which we call planets, or to problems of pure mathematics, makes no difference. Only for me the latter holds a higher charm."

These words reveal his thoughts on the final destiny of man's soul and the deep religious conviction which was tied so closely to his outlook on science. Science was for him the instrument for revealing the immortal source of the human spirit. In the years of his full powers as also in later years when he saw life's limits drawing closer and the goal of existence almost within reach, its wide vistas gave him comfort and confidence.

Gauss' character was an odd mixture of virile force, of lofty self-confidence and of quiet childlike modesty. He was well aware on the one hand of the mighty forces he could set in motion with his intellectual levers; and in truth we have never seen a man with a more striking presence. While others appeared as of our own kind he stood among us like a superman. Yet on the other hand he was the plain, simple man, deeply humble before that all-penetrating Intelligence re-echoing from one sun-system to another throughout the Universe.

If ambitious plans had entered Gauss' life his genius and intellectual powers would have made them easy of attainment. But all the honors paid him had to be carried to him; never did he reach out a hand for them. In youth and in old age, up to the end he remained the same simple scholar. A small study, a small work-table with green cover, a high desk painted white, a narrow sofa and after his 70th year an arm-chair, a single dim light, a bedroom that could not be heated, simple food, a dressing-gown and velvet cap, these were apparently all his needs.

In such wholly unadorned surroundings his powerful spirit worked on, charming forth from their divine source new inventions, new concepts, ever moving toward that consummation which he sought here and has now found there.

His unwavering conviction of personal life after death, his firm faith in an ultimate Order, in an eternal, just, all-wise, all-powerful God were the basis of his religious life, merging with his scientific achievements into full harmony. He said one day: "There is in this world a joy of the mind which finds its satisfaction in science, and a joy of the heart which expresses itself chiefly in men's efforts to lighten one another's cares and burdens. But if it is the plan of the Supreme Being to create beings on separate planets and for their enjoyment to grant them but eighty or ninety years of existence, it would truly be a cruel plan." ("A pitiable solution of the problem", he called it another time.) "Whether the soul lives eighty years or eighty million years, if it must someday perish then is this life-span a mere respite from the gallows. Eventually it would count for nothing.

"One is therefore forced to the conclusion, for which without any strictly scientific proof so much else

speaks, that in addition to this material world there exists still another, a second purely spiritual world-order, as diversified as this in which we live. And in this we are meant to share."

This divine conviction was food and drink to his spirit till that quiet midnight when his eyes were forever closed. The time has now come when he belongs to the world of the Spirit, that world of which the aged Bolyai said in a letter, having compared this life on earth to a mining operation: "On and up go the precious mine-lights, leading the soul thirsting for Truth and Love from the ever widening endless level of mystery on to its source; from the Ocean of Tears from which we can remove but a few drops, on to that shore where no more fall."

This was Gauss whom we have been privileged to call ours. His spirit is gone hence. Like a comet leaving a trail of sparks behind he streaked through the twilight of this earth-life. He is gone and we will see no other like him.

Only love and profoundest reverence have enabled me to write these pages. I would consider myself more than repaid if in any degree they could meet the wishes of him who is gone. As a devout tribute to the departed I place this Memorial on that green mound on the very day when seventy-nine years ago the great man first looked on the light of this world.

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